Notes
written by
Benjamin Rush

of Calcareous Earths

manner they produce their Effects. I shall give you my own Conjecture upon the Subject tho' the Causes of y^e Fertility of Grounds are not properly ascertained. Clays are probably the Basis of all Soils, but are unfit by themselves to support Vegetables, without y^e Mediation of some other Bodies to render them properly diffusable in water. Putrefied Bodies seem best suited to this purpose. For if you expose a portion of stiff Clay to the falling Rains (which are generally replete w^th putrid Matter) it in time becomes readily diffusable in water,

of the Fertilization of Ground.

Shingey in its texture & an extremely proper matrix for the nourishment of Plants. I suppose Magnesian Calcarious Earths act only by promoting Putrefaction & perhaps in their calcined state producing some Change in y^e^ Structure of the Clay since it then becomes a saline Body.

Calcarious Earths are also employed when calcined as Cements in Building. The workmen find that y^e^ Cements Obtained from Chalk & Limestone are endowed w^th^ different Qualities, the one w^ch^ this Variety depends we have not yet determined. The Earth ought to be taken

free from any foreign matter, especially
other Earths w^ch frequently disappoint
us of the Quick lime by various
means as Vitrification &c.

The Caustic Calcarious Earth dissol-
-ved in water becomes "Lime water," the
so much celebrated medicine for dissolving
Calculi of the Bladder & Kidneys. It is
also called Bl. Calcis, & the Liquid Shell.

In Arts the Lime water is employed
for the purification of Sugars, on w^ch it
acts chiefly by absorbing the Acid of y^e Saccharine
Juice, w^ch otherwise w^d prevent the Granu-
-lation of the Sugar, & retain it in the

Of Calcareous Earths.

Form of a Syrup 2nd It unites w: 4 lb 2 Oil of the Juice into a Soap which may be easily separated by washing.

By restoring the water & Mephitic Air which the Quick lime loses in Calcination, it becomes a Corrosive Salt or the common Cement for Building It will appear evident that the Lime must be in Situ, before Calcination take place firmly, or in other words before the Quick-lime becomes mild. but as in that State it forms a friable Mass extremely liable to Dispute when dry, we must endeavour to obviate the Inconvenience by the addition of some

of Calcarious Earths

other Body which is most commonly Sand. the Effects of which I shall illustrate in the following manner. If a Cubic Inch of wet Clay is exposed to the Heat or Air, it will contract in drying $\frac{1}{10}$ of an Inch, and form a Fissure equal to the Space contracted: but if 100 Cubic Inches of Sand be added, & the Clay equally diffused thro it each portion of Clay will be a hundred times less than before, and will consequently form Cracks proportionably less.

Gypsum or Selenites is a Crystalized Salt compound of Vit: Acid & Calcar: Earth.

of Calcarious Earths

Its chief use is to take off the Impressions of moulds. for this purpose its water is extracted when like other Mineral salts it falls to powder. But when y^e^ water is restored it again concretes or dureth, so that the nicest lines of a mould are impressed upon it. The preparation of Gypsum in large works must be performed in Furnaces. but for private practise we may employ an Iron pot. The Gypsum must be put into the Pot in Fragments about as large as Hens Eggs. Soon after the Heat is applied it begins to boil: when y^e^ boiling ceases

we must remove it from the Fire, be=
=cause the water of the Gypsum is then dissi=
=pated, and if the Fire is continued after=
=wards, a Decomposition of the acid
takes place. The Figures usually made by
Gypsum are rough on the surface, but they
have lately found that by the addition of
Glue it will receive a polish like Marble,
and that by the addition of various Colours
it may be rendered very like Marble.

Of Crystalline Earths

These have been called by Authors Vi-
-treous, from their transparent Ap-
-pearance, tho very improperly, for they are
not vitrifiable when pure by any degree of
Heat. they are hard enó to strike fire
from Steel — not acted upon by any mix-
-tures — and remarkably first imp: to
Fire. Mr Cronstadt divides y: Cryp:
-talline into two kinds 1: Tho truely Crystal
-line or those wch are not fusable in any
Heat 2nd into such as are to be fused by
common Fires. of this kind are his
Granates, such as their Fusibility seems
to depend upon y presence of Mr: Alum,

I think they ought not to be considered as a distinct kind.

They are also divided into pure & impure. Of the latter sort are common Sands, and Spar of a particular sort which break into Fragments of an irregular Shape. Of the former are precious Stones and Crystals, whose Shapes are more or less angular, & such as break into Fragments alternately concave and convex, as Cornelians, Agates, Common Flints &c. When joined w^th^ Alkali they become fusible & form Glass. This ought to be done w^th^ a proportion of

Earth to Alk ▬ :: 3 : 2 . if a greater Propor= =tion of Alkali be added it becomes Soluble in Acids, and the Compound precipitated is found to be an Absorb^t Earth.

Crystalline Earths are chiefly employed in y^e Manufactory of Glass, w^ch Art is not even now by any means perfect. You will see an Acc^t of the Process in Cramer. I shall only add that many People have been mistaken in thinking y^e transparen= =cy of Glass depended upon the use of cove= =lesp Substances: for a proper Adjust= =ment of several Colours produces y^e most perfectly transparent Glass, & such as y^e Workmen call a transparent Black. —

Of Argillaceous Earths.

There have been many Disputes concerning the Division of these Earths. Mr Pott thinks that there is only one kind & that the various Species which have been described, are nothing more than evident Additions of other matter. we shall however give the distinguishing properties of Argillaceous Earths from many other Classes. They are never hard enough to strike Fire from Steel; they are partly dolubleim diss when dry: they readily absorb a large proportion of water, & acquire with it great Viscidity: if this mixture be exposed to the action of the Fire, it acquires a remarkable hardness. on this acc[t]: they are in

Of Argillaceous Earths

great use among the Potters, & workers of various kinds of Porcelaine & Earthen wares.

Formerly we were ready to acknowledge, that the three kinds of Earths we have denied, were pure homogeneous Bodies, quite distinct in their nature & properties from each other, so y: we were doubtfull whether as some Authors have imagined, there was a primogenial Earth the Basis of all the rest: but Mr. Margraaf by some late Experiments has entirely removed that Doubt concerning a primogenial Earth. He tells us that Clay is acted upon by any

of Argillaceous Earths

Acid, especially the highly concentrated Mineral Acids, with the Assistance of Heat. by such Application he discovers Clay to be composed of a Crystalline & such an Absorbent Earth as enters into the Composition of Alum. in the Decomposition of Clay by the Vitriolic Acid and the consequent Formation of Alum I shall observe the following Circumstances. First the Alum cant be made by the Addition of Vitriolic Acid & Earth without an Addition of Alkali, w^ch tho it occasions some precipitation gives rise to the production of fairer well crystalized Alum. —

of Argillaceous Earths

with Respect to a primogenial Earth, we shall observe, that Clay does not seem to be such, since it is separable into the Crystalline & Absorbent. it may therefore be a Subject of Inquiry whether Absorbent & Crystalline Earths are not Clays decompos'd by some means or other? - Margraff in some of the following curious Expt. that water by Filtration & Evaporation is converted into an Earth compos'd of Crystallized Absorbents, & is perhaps a pure Clay. Margraff says also that by repeated Distillations the Sediment of the water becomes

greater. Clay w: a proper Addition of
Sand & Calcarious Sub: is extremely proper
for making Crucibles. —

of water

We shall now consider the 5th Class of Bodies, viz: water and refer you for a general Definition of it to 2d Objects of Chemistry. —

Some have supposed that water is chiefly supplied to the Earth by the precipitation of vapours exhaled in form of Rain on y: Tops of Mountains, thro' w: it filtrates breaking out in Fountains Brooks &c. Others suppose y: the atmosphere supplies the surface of the Earth with a very small proportion of its water: but that waters continue to filtrate thro' the various strata till they meet w: subterraneous Lakes w:

drives them back in form of vapour w: rise till they are condensed by y^e^ Mountains as it were by Alembics. I am inclined to think that y^e^ former opinion is manifestly true, because in opening mines I am informed that they are often interrupted w: water, after descending below y^e^ common Level when rain waters penetrate.

From whatsoever source derived, water in passing thro' numerous strata is frequently impregnated w: various substances.

When waters are so strongly impregnated

of Mineral waters

as that we may refer their Smell or Taste to
other Bodies they are called Mineral, be-
-cause they are most commonly impreg:
-nated w: Min: Substances. but when y:
Matters are of such a Quality or in such
Quantity as not to become Objects of
our Smell or Taste the waters are called
Common. or such as we use for com-
-mon ~~Domestick~~ purposes in Life. -
Independant of any foreign matters adhering
Water is only of one kind, tho' by no means
a pure Elementary Body, as some have
supposed, since it is convertable into
Earth under a particular Mechanism. -

of Common water

Common water as obtained from Fountains is never entirely free from foreign matter adhering more or less. When we cannot distinguish the matter present by the Taste or Smell we must then have Recourse to other Tests. When they are impregnated w: Earthy matters we may precipitate them by the addition of Alkali; w: Acids by the addition of Solution of Silver in Nitrous Acid. but Sugar of Leads for the most perfect Test, since it will cause Precipitation in water on w: q: & other Means produce no Change. The Specific Gravity of water has been proved by some as the most perfect mark

Common water

of its purity; but is erroneous since the weight of water depends upon y^e^ Quantity of Air present.

M^r^ Margraff finds that Rain water kept in a considerable Height in y^e^ atmosphere is equally pure w^th^ any that can be obtained by repeated Distillations. it is entirely free from all fossile matter, but always retains a putrefactive substance of Animal & vegitable Origin.

Exactly similar to Rain water is y^e^ of Snow & Hail, only that the latter contain much less Air, nor can we discover the frigorific Salts w^ch^ some

have not peculiar to them.

Dews are less pure than any waters of the atmosphere. The waters of Lakes are very pure, because they are generally supplied by Rains from the Sides of Hills which have not filtrated thro many Strata. They also are purified by the Subsidence of Intrescent Matter; which probably forms the Mud usually covering the firm Foundations of the Beds of Rivers & Lakes. That water is very speedily purified appears from the short time in which Rivers regain their purity after receiving the Discharge of Filth from

of Common Water

~~neighbours~~ populous Cities. We may generally determine the purity of Water by the Distance at wch it issues from the common Height of the Adjacent Hills.

of Mineral Waters

Physicians & Chemists have frequently attempted to investigate the properties of Mineral Waters, & the Causes of those properties. But as most of them (for want of Chemical Knowledge) either have not known wch Bodies were truly fossile, or wch of the fossile Substances could be united wth Water in a Separate or Compound State, their Labours have proved in general very unsuccessful. This is the Case of Dr Nutty

of Dublin & his Countryman D^r Lucas
who w^th much arrogance has attempted
to correct his work. I shall give some
general Observations on this subject,
that you may be assisted not only in
discovering the Faults of others, but also
in correcting them by your own Experi-
ence.

Mineral Springs are generally divided
into the Acidulæ & Thermæ. The first name
is applied to all Springs sensibly impre-
gnated w^th fossile matter of any kind,
the Impropriety of which is evident. The
Thermæ are distinguished on Acc^t of the

Of Mineral waters

Heat which they always discover. This curious Phaenomenon of the Heat of Springs in the Effect of a Cause not easily investigated. Some suppose y: in running over inflamed Pyrites they become hot, or that this Heat is derived from subterraneous Fires; but as many waters have preserved a constant Temperature of Heat for upwards of a thousand years, it is improbable that any Quantity of Pyrites sho: be colour'd inflamed without producing a Change either in the Direction or Temperature of y: water. Neither do we observe y: the

of Mineral Waters

Effects of Subterraneous Fires are invariable and always permanent as in Volcanoes &c. Others imagine; the Heat is produced by the Impregnation of such Bodies as generate Heat in fermentation. But we often find Fluids of such purity, as not to be sensibly impregnated w: any matter whatever. —

Such Waters only are called Mineral, that are impregnated w: Fossile Bodies; nor do we find any other except where y: Stream is continued along the Surface of y: Ground to some Distance. The Reason of this seems to be y: by a particular Oeconomy

Of Mineral waters

Of Nature all Animal & vegitable Substances are converted into Fossile Substances, after they are washed to a certain Depth in the Earth. —

In our Inquiries after such Fossile Bodies as impregnate Min: waters, we shall proceed in the usual Order beginning w:th y:e Saline.

Among y:e Acids none can be vouched properly Fossile productions, except the Vitriolic & Muriatic. the Vit: Acid is universally dispersed or corrodes Fossile Substances, y:e we rarely find it separate in waters, except when suddenly washed out after a Decomposition from some

of Mineral Waters

of the Substance. The Pyrites of Coal Mines often dilaquate when the Air is admitted, and the Vitriolic Acid by y^e^ means is sometimes washed out by Showers w^ch^ have penetrated thro' their Cavities. And the Case happens when we

Waters are seldom impregnated with the Muriatic Acid in a separate State, tho' very frequently combined w^th^ Common Salt, and fixt Ammoniac. M^r^ Cronstedt also informs us y^t^ the latter is very rarely found in Mineral Springs. —

of mineral waters.

That Veg: Alk: is entirely excluded from the fossile Kingdom. If it has been at any time found in y^e^ Bowels of the Earth its Duration then is very short & it would soon probably have been converted by the Oeconomy of the Earth into a Fossile Alkali. Hence we may conclude that Min: waters are never impregnated with Veg: Alk: or its Compounds.

The Fossile Alk: is very frequently found in Min: waters, both in a Separate & compounded State, but more frequently in the former than has been imagined. In the latter State it is found united with

of Mineral waters

Fossile acid into Common & Glauber's Salt. The Spurious Salt of Glauber compound of Oil & Magnesia often impregnates Mineral water than the genuine Neutral, and has many times been frequently mistaken for y^e true Sal Glauber. Volatile Alkali never exists separately or formally in y^e Fossile Kingdom, but y^e it may be produced from Mineral waters in consequence of their containing Hepar Sulphuris. Which by a properly conducted Distillation always gives out a Vol. Alkali.

We must take Care in reading Authors

of Mineral waters

not to be misled by Terms. Thus Dr. Short says he found Nitre in almost every mineral Spring: but he has mistaken it for the spurious Sal Glauber. Dr. Hill has also mentioned his Alcripsum which is nothing more than Fossile Alkali.

Oils both Animal & Vegitable are exposed upon the surface of the Earth, tho we have never discovered them in the Bowels thereof, & consequently not in mineral waters. Naphtha, or Fossile Oil frequently flows out on the surface of Springs, & is sometimes combined with them

intimately, as Essential Oils are combin
with distilled waters. Naphtha is sometim
combined with Fossile Alkali into a Soap
2 forms with are called Saponaceous Wat
Sulphur alone admits of no union wi
water, and tho it is sometimes very
minutely diffused therein, yet when the
water is at Rest, the Sulphur subsides
it often unites with Fossile Alk: into a
Hepar, & thus becoming Soluble, it fre
-quently impregnates Min: waters. T
Taste Odour of Hepar Sulph: is so very
disagreable, that from such Springs as
appear to the Senses very strongly im
-pregnated

of mineral waters

we often cannot obtain one grain in substance, and only discover its presence by the Taste, Odour, and Change of Colour after Immersion therein. Waters then never contain Sulphur except as Hepar. th w: it we often find Sal Glaub: & Sal Com= =mune.

Among the variety of M: S: very few impregnate min: waters: partly because few of them are soluble in water, partly because many of them are not soluble in Profile Acids, & partly because when they are dissolved they are liable to Precipitation by other matters w: are diffused thro' Earth.

# of Mineral Waters

Of all the M.S. except Zinc Copper & Iron are most strongly attracted by Acids and are also the most frequent Metalline productions of Nature. There therefore we may expect to find most frequently present in waters, and of these two, the latter because it is more generally diffused thro the Earth, & most strongly attracted by Acids. They are never founder = ept in a Saline State. Iron may be combined w. Acids, Alkalies, or Neutral Salts, but most frequently w. the first: yet it is so difficult to collect Green

of mineral waters

vitriol in its proper form from Min: waters
that some have denied y^e^ Existence of
Iron in a saline state.

The Difficulty may be removed by con-
sidering that the Acid of green vitriol,
is in a vol: State, so y: when Vitriol
is exposed to the Air it very soon loses
its Acid, & degenerates into an Ochre.
It has been long found y: Chalybiate
Some a certain vivifying Spiritly keeping,
the properties of w: are not exactly known.
Query is, it not the phlogiston Air which exhales
w: the volatile Acid? —

The mineral waters of Copperau by

no means so frequent as the Chalybiate, which depends upon Reasons already given. Naturalists have supposed y: the Copper is never presented in a saline State, but I have a Specimen of pure blue Vitriol collected from a Spring in Britain. The Difficulty of Obtaining blue Vitriol in a Crystalline form as we said of Green gave Rise to y: Suspi-cion of its Absence entirely from Min: Waters. The only M: S: remaining w: we can expect to find in Min: Waters is Zinc.

This is readily obtain'd in liquid, pre-cipitated

Iron & Copper from Ox, and is now found to be a frequent production of nature; and yet Chymists allege y: it is never found in Min: waters. It must be acknowledged y: its presence is rarely discovered. Tho I have seen a Specimen of White Vitriol from Min: water. We did bid him to enquire w: is the Reason y: Zinc is so rarely present in Min: waters? Perhaps it is because Lapis Calaminaris & Luda Galena are not readily Solvible in Acids or rather because we never suspect it

in Waters. But do we not not posess proper means of discovering its presence — By treating the Residuum of Min. Waters w: Copper as in making of Soap we might always determine whether Lime is present in any State. —

Earths are found more or less in all waters, and none more frequently than the Species of Abrobeat. Calcarious Earths w: are not soluble in Water except in a State of Quick lime, are frequently found suspended in Water probably by Solution, since Exposure to the Air & several Additions cause a precipitation

Of Mineral waters

of Earth which now happens in Dissolution.
— From this Phanomenon we are led to enquire in w^h manner it is rendered Soluble? — perhaps by a very volatile kind which evades unnoticed: but then the precipitated Earth would retain some marks of Corrosion. — perhaps it is in the form of Fresh lime: but if this is the Case how can we imagine y^t the Calcination had been effected: this however is the most probable Supposition: and if found to be true it will confirm the Opinion that Lime water acquires its Taste & Colour only from an Impregnation contracted in

burning: since these waters are entirely without that peculiar taste & Odour. May not Lyfile Alk: dissolved in wa-ters dispose them to dissolve Earths w. Otherwise they would not affect? — These kinds of waters are called petrifying, be-cause by insinuating themselves betwe the Pores of Bodies over which they pass, they leave their Earthy particles, & by that means produce Petrifactions.

Chrystalline Earths as they are not dissoluble in Acids are never found in waters except in such small Quantities as not to form mineral Water, And even

these small portions are in a State of Diffusion only.

Argillaceous Earths impregnate waters as they are partially soluble in them: but these are most frequently in a diffusable State. From the extremely minute Diffusion of w.ch Clays are capa- ble has arisen the mistake of Argilla- ceous Earth in water for truly Sapona- ceous Water. We have already said y.t water is convertable into an Earth composed of the Absorbent Crystalline which are also the Ingredients of Clay. Ours may not all the Clay upon Earth

have been formed thus from water?

We formerly mentioned 3 Species of Absorbent Earth viz: Calcarious Magnesia & Earth of Alum. These may be united w: the Lapidile Acids into Earthy Salts tho we are only acquainted w: one Combination of the Muriatic. Vit: Acid, & Calcarious Earth produce Selenites. This is a frequent Production since it is very generally the Cause of hard waters such as decompose Soap. They are to be remedied by y: Addition of fixt Alkali. Vit: Acid & Magnesia form the Spurious Salts of Glauber. &c. it is

of Mineral waters

abundantly more frequent than the genuine Neutral. they are also often mistaken for Each other. Earth of Alum uniting w: the vitriolic Acid is often found in the Bowels of the Earth, & may therefore impregnate Min: Waters: yet it is rarely found because its Attraction to Acid is weaker than the other Absorbents, than Iron, or Copper. The Combination of Calcarious & Mur: Acid mentioned before is called fixt Ammoniac. this is seldom found alone, but frequently accompanies Comm: & Glaub: Salts. The following is a Table of all the Bodies m: w: impregnate Min: Waters. —

Table of Mineral waters.

Aqua minerales simpliciores.

ex

Salinis

1ma Alkali Fossili.

2nda Neutris a. Sale glauberi b. Sale marino

Inflammabilibus

1ma Oleosis Fossilibus.

2nda Sulphureis.

metallicis

1ma Ferro

2nda Cupro

Terrestribus

1ma Calcariis

2nda Argillaceis.

Table of Mineral waters

Aquæ minerales Compositæ

1° Salinis variis ex { Because we seldom find water impregnated with Gaseous vitriol without common Salt adhering & vice versa.

2°: Salinis Sulphureis - Hepar Sulph. &c

3°: Salinis Metallicis, Vitriolis Cupri & Ferri.

4°: Salinis terrestribus. Selenitis Sal Alembroth

We shall here subjoin the Table of Elective Attractions.

Explanation of the Characters contained in the Table. ——.

 Acids in general.

 Vitriolick Acid

 Vol: vitriolic Acid.

 Nitrous Acid.

 Muriatic Acid

 Vegi: Acid

 B: Acid of Borax.

 Acid of Tartar

 Alkalies in general

 Fixt Alkali

 Caustic fixt Alkali

 Volatile Alkali

 Caustic Vol: Alkali.

⊖ Neutral Salts.

✱ Ammon: Salts.

🜍 Phlogiston.

°°° Oils in general

⁘ Essential Oils.

🜍 Sulphur.

🜈 Alchohol.

⚲ Æther.

Md:

M precious Metals. M.

☉ Gold.

☾ Silver.

M Base Metals.

♀ Copper.

♃ Tin.

♂ Iron.

♄ Lead

☿ Mercury

♁ Regulus of Antimony

Z Zinc.

B Bismuth.

K Cobalt.

N Nihil.

P. Platina

♁ Arsenic.

V. Absorbent Earths.

V Quick lime

M Mag: alba.

▽ water.

🜁 Mephitic Air.

elaud.

der=

two

upon

has

uts.

peato

D:

ina,

has

ften

ight

come

♄ Lead

☿ Mercury

♁ Regulus of Antimony

♃ Zinc.

B Bismuth.

K Cobalt.

N Nihil.

P. platina

♂ Arsenic.

∀. Absorbent Earths.

∀ Quick lime

M Mag: alba.

∇ water.

A Mephitic Air.

№ 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
☌	☍	☉	☽	☽	⚹	☊	△	☉	☉	▽	☌	MS.	♄	♒	☉	▽	▽	♀	☾	☾	☾	☿	☿	♃	♂	♒	♑	♂	♓	♎	♎	
♎	☉	1–4 I	1–3 I	1–4 I	1–4 I	1–4 I	MS.	☽	☽	☽	☍	☽	☽	☽	♋	☉	♀	☉	♄	♄	☿	☉	♄	♂	♒	♂	♑	♋	♎	☿	☽
☌	▽	♌	♌	♌	♌	♌	▽	☽	☽	☽	△	☽	☌	☽	☊	♀	☉	♈	♀	♂	✳	☾	♐	♄☾	☿☾	♀	♂	♂	♂	☉	1–4 I
▽	♏	♑	♂	♃	♂	♃	☉	☽	☽	☽		☽	☌			☉						♄				♄☾	♂	♀	♀		☉
♏	♏	♐	♐	♒	♀	☉	♏	⚹	⚹	⚹		⚹	⚹									♃						♃	♄		♌
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Remarks on the Table.

1. It is doubtful whether the VA be right placed.

2. III. By the Figures (1—4 &c) it is understood that the first four Spaces of the two first Columns are to come first.

3. $\frac{1}{IIII}$. This is pretty universally agreed upon by all Chemists except D^r Lordyce who has endeavoured to correct it by Experiments. — for this Reason I have added $\frac{2}{IIII}$ repeated according to his Determination. perhaps D^r Lordyce is mistaken w^h Regard to Platina, for all Chemists say that this Substance has no Relation to ☿. But Platina is often united w^h Iron and y^e Circumstance might mislead him. M^r Margraf has given us some

♄
☿
B
E
A
F
♂
∀
N
▽
△

Remarks on the Table.

a 1st It is doubtful Whether the ☿ be right placed.

v III. By the Figures (1—40) it is under=
stood that the first four Spaces of the two
first Columns are to come first.

I
IIII. This is pretty universally agreed upon
by all Chemists except Dr. Lordyce who has
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- for this Reason I have added 2 IIII repeated
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Remarks on the Table.

Experiments 2 & 3 very much disturb the Column of ☿. he finds that tho' Sprei-
-pitates Copper in the Cold, yet in that
the contrary happens. perhaps this depend-
upon a principle that Heat encreases
the Solution of Bodies when seperate, but di-
-minishes it when they are combined.

VIII. This is a new Inquiry & an extre-
-mely useful One. Dr. Alston for preserving
Water at Sea proposes that a Quantity of
Lime should be thrown in. this gives it the
Properties of Lime water in which State it
will keep for Ages. When it is to be used he
directs that Magnesia Sh. be added. this

Remarks on the Table.

is soluble in water, but furnishes Air to y^e Lime, w^{ch} then falls to the Bottom w^{th} it. and leaves the the water pure. I place M: S: uppermost because the Addition of mild calcarious Earths restores them from Calces to a Metalline Form. —

IX. I have put the °° and [symbol] together, for I do not know whether there is any difference in their Attraction to ⊖r. Balsam of Sulphur may be united wholly w^{th} ⊖r into a Soap.

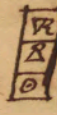
XII. I have not given a detail of the Liuds in this Column; tho' they are in the same Order as in the 9^{th} & 10^{th} Columns.

XIII. This stands as given by Geoffroy.

Remarks on the Table

But it is most doubtful of all, and you see the two next Columns are Exceptions to it.

XIV. Possibly ☉ - may in like manner come in with ♃.

XVI. Perhaps this is not well founded, tho' agreable to common Experim: I rather think the Column shd stand thus 

XVII. This shews that the ♁ only takes the water that enters into Mixture w: it in Order to Crystallization, and that when it has acquired ♁: and in a mild State then ♀ will precipitate ♁ from ▽.

XIX. This Character ☉ stands here for

Remarks on the Table

all Inflammables that are soluble in

V.

XXII. I have not ascertained by my own

Experiments the Truth of this Columne.

XXV. This is for the Seperation of Tin and

Silver. —

— —

Of the Chemical History of Fire

Of the Chemical History of Fire

ally y^t we can undertake to deliver, will be something of the natural History of Fire: an Agent universally found, and the most important to the present purpose, as leading to the general History of Qualities.

In treating this Subject I shall pursue the Analytic Method entirely; taking care not to advance new Theories, or such as being ill-grounded may lead to Error, but to collect & digest in proper Order those Facts which have any Relation to

# of Fire

the Business in hand. perhaps now & then I shall reason on some Facts (for this is extremely allowable) & draw perhaps a few unexceptionable Theorems in general however I shall only enumerate known Facts; and those as they are relative 1st to the Generation of Heat 2nd its Communication & 3d as they are relative to its Effects.

we shall first treat of 1st Generation of Heat. —

Of the Generation of Heat

It may be expected that I should here give a Definition of Heat or Fire. but this is very difficult, & perhaps not to be attempted ~~by me~~ w^ch^ I dare not 'till after a full Induction of Facts. it is only necessary to premise here y^t^ by fire here we mean that power w^ch^ excites y^e^ Sensations of Light and Heat. these are usually joined together, a certain Degree of Heat producing Light, and this in a certain proportion affording Heat.

Some Philosophers in y^e^ Subtile Reasoning have agreed, y^t^ the term Quan^t^.

Of the Generation of Heat

Generation is improperly applied to Heat. for say they, Heat is only collected from heated Bodies, being thus communicated by Bodies to each other, hence they conclude that no Heat can be properly said to be generated. Again Heat always endeavouring to restore itself to an Equilibrium will be negatively diffused from a heated Body to a number of similar & contiguous Bodies till all of them acquire equal quantities of Heat & hence if one Body be more heated than the Rest, it will

Of the Generation of Heat

lose so much of its Heat as is sufficient to restore an Equilibrium between all the Bodies. But if by any Contrivance Heat can be produced in one Body without diminishing it in another, truly in that Case we may say w: Propriety: Heat is generated.

The Means of producing Heat in Bodies are various. The first I shall treat of is the Increase of Motion excited in any Body, to w: some have altogether referred the Increase of Heat. This is effected by Mechanical Means & is therefore called

Of the Generation of Heat

The Mechan: Generation of Heat. It is produced either by Attrition, Percussion or Collision. Altho' these may in some Degree appear to be the same, yet it is requisite here to consider them seperately.

1: Attrition or Friction. common Experience informs us that by this means Heat may be excited between two solids so as to produce Flame. we may here observe as it is not foreign to our purpose that no Heat can be produced by Attrition in Fluids. — The Heat may occur in turning seems at first

Of the Generation of Heat

light to prove y^e^ contrary. but we must consider y^t^ in these as well as many other cases the Heat produced is owing to a chemical Decomposition. Therefore till it is proved y^t^ simple ho: -mogeneous fluids can be rendered hot by Agitation I cannot allow y^t^ they are capable of producing Heat. we find also y^t^ ~~the~~ Solids produce a greater Degree of Heat as they become firmer, & are further removed from a fluid state. - thus Stone produces more Heat than wood, & metals still more than either.

of the Generation of Heat

the next Circumstance for determining the Quantity of Heat to be produced in any Body, is the Roughness of the Surfaces applied & moved on Each other. by this means they interrupted cause Oscillations one more or less frequent in proportion to the number of ~~Oscillations~~ Prominences. this admits of Demonstration: for as the Surfaces of Bodies become more polished less Heat is produced in them by a given Quantity of Friction. —

Mechanics find than a Gudgeon of Steel will turn much easier in a Brass, than a Steel Socket. —

Of the Generation of Heat

Acording to Muschenbroeks Experim.ts they differ also in the time of acquiring Heat, and have Diff.t Quantities of Expansion in the same degree of Heat. it is not easy to say whether this Difficulty of motion happens because y Attraction of Iron to Iron is stronger, or because the Inequalities of Iron are better adapted to the same Metal than to those of Brass. we may likewise Obs.e here that when Iron is employed a Degree of Magnetism is acquired, & some Particles worn off by still adhering contribute somewhat to y Grinding away of a

Of the Generation of Heat

Gudgeon in an Iron than in a brass socket. But as we seldom or never can obtain a polish so perfect as entirely to prevent the Generation of Heat it is necessary to interpose some substance capable of filling up all Inequalities of the surfaces. The most effectual for this purpose are Oil and Black Lead, or W. last may be reduced to an impalpable powder.

The Roughness of surfaces, & the hardness of Bodies being given, the Degree of Heat will be proportionable to the Impetus applied, & this again depends

of the Generation of Heat

upon the Quantity of Matter & Velocity of the moving Body. Velocity encreases the Momentum, & accumulates the Vibrations by wch they become more dense, or a greater Heat is generated. This may be proved by pressing a Rope slowly & then very rapidly thro a Body: it will be found that a Degree of Heat in the latter Case will be most considerable. Here a Question may be examined if whether the Increase of Lumiferous encreases the Heat produced? It certainly does in some measure, as the Centers of Oscillations are encreased

in number. The Rule to be observed
herein is this, that Increase of
Surface does not compensate for Dimi-
-nution of Velocity. for if the Edges, and
then the Sides of two broad thin Bodies
be rubbed together w:a given velocity, the
Heat produced will be greatest in y Latter
Case; but if the velocities in each Case
be reciprocally proportional to the
Surfaces applied, the Heat produced by
the Edges will be far y most considera-
-ble. contrary therefore to these undoub-
-table Experiments Mr Martin in the
Encl: to his Essays alledges y: y Decay
-cation of the Electrics is continued to

Of the Generation of Heat

disperse the Heat equally thro' the whole Body, the extent of Surface in their Extremities ommitting for y^e^ slower motion.

The next proposition I shall lay down is, y^t^ any Body must be fixed in Order to have Heat produced by the Friction of another. This may be confirmed by various Experiments. E.g: if a piece of Iron be fixed in a Vice in Order to be filled, or a Rope be pulled rapidly thro' a fixed Block we shall find y^t^ a great Degree of Heat will be excited in the fixed Bodies, while y^e^ moveable

of the Generation of Heat

have no Heat but w^ch they receive from being in Contact w^th the heated Bodies. If both the Bodies be moveable the Force applied by the moving Body will be chiefly spent in causing y^e motion of the Whole, and not in producing Oscillations. Hence it is plain y^t Heat cannot be produced by the motion of Fluids on Fluids because a Fluid cannot be fixed. This Conclusion is further provd by Observing y^t a Fluid interposed between two solid Bodies prevents the Generation of Heat. in Answer to this however several Objections are added.

Of the Generation of Heat

to the Heat produced in Fermentation; but this is certainly owing to a Decomposition of parts, and is therefore foreign to the present Inquiry.

To Arguments 8th. "This Opinion it is alledged that Quick Silver agitated in a Vial, and a Cannon Ball discharged both acquire considerable Heat. I grant that Heat is produced in both Cases, but at the same time I must observe that the Instances are by no means conclusive. For in the first Case the Mercury is agitation is chang-

into a Solid powder, wch being rubbed
agst the Sides of the Phial will un-
doubtedly produce Heat. in ye second
Case the Bullet is surely heated very
much by ye in shaping from ye Gun by
violent Attrition agst its Sides & by
the Inflammation of the powder.
Hitherto it is proved yt ye Bullet
grows gradually hotter from ye time
it is discharged from the Mouth of the
Cannon, no certain Conclusion can
be drawn from the Last. upon the
whole we may conclude that no Heat

of the Generation of Heat

can be generated in Fluids by any Mechanical Motion, & hence y^e Absurdity of the Theory by which Animal Heat is supposed to depend upon y^e Motion of the Fluids &c. each other, & &c. y^e Sides of the Vessels. It is further to be observed w^th respect to the Mechan^l Generation of Heat, that it depends rather upon the State of Aggregation than of Mixture; and particularly y^t it does not depend upon y^e Quantity of Phlogiston contained, except when we desire to excite actual Flame, & then y^e Body containing most Phlogiston is to be

shown. Thus Stone by Attrition affords more Heat than wood. Tho' wood contains by far the largest Quantity of Phlogiston or inflammable Matter. This takes place even in different kinds of wood. E.G. Mahogony is capable of more heat from Attrition than any other wood, Altho' they may contain more Phlogiston. we may make the same Observations on M.S. - Iron is capable of having more Heat excited than Lead, & indeed it has more inflammable Matter. but Zinc & w: contains more Phlogiston than

Of the Generation of Heat

Iron is far less capable of Heat by Friction. The Quantity of Heat produced by Friction depends in a great measure upon the Hardness of Bodies, & consequently on the State of Aggregation, and not of Mixture, except so far as the latter influences the former.

Thus then we see it is from y^e Vibrations produced in any Body that its Heat is generated. These Vibrations are supposed to be excited in a very subtile Fluid, interposed between the particles of all Bodies, w^ch from Sr Isaac Newton who tho' not the first Discoverer was y^e first

Of the Generation of Heat

Author who treated the Subject fully has been called y^e^ Newtonian Ether.

That such a Fluid exists is at present the generally received Opinion. it is not convenient for me now to enter far into the Dispute. I shall only observe that upon exciting Motion in any Body a new subtile matter seems to be introduced at its pores. now altho this is very probable; yet it must be Objected, that if it was really true, the same motion wd produce Heat in proportion to the Number of contiguous Bodies. this however does not happen. for this

Of the Generation of Heat

the Heat of the surrounding Bodies diminished. in Electrical Experiments the matter is collected & accumulated in the Body without Diminution of it's rest from wch it is derived. these Arguments however are not conclusive: nor can any thing be determined wth certainty, till a method is found of stopping the propagation of Heat as we do that of Electrical Matter. here a Question occurr that I shall propose without attempting to answer. Whether on ye common Hypothesis that Heat does arise from the Influx of a subtile matter, is ye Heat excited in this matter owing to Agitation?

Of the Generation of Heat

It may indeed be remarked y^t Fire or its Matter is common to all Bodies without Respect to them as Mixts.

The Agency of Fire is so very extensive that the Explanation of it requires particular Attention. in Order to do this, the several Facts relating to y^e Subject ought to be collected: but this is a Labour which few are either willing or able to accomplish. Many of the many Hypotheses which have been formed I shall only mention the three principal.

The 1^st of these Opinions is, y^t the Heat of Bodies depends on Motion, & one

Of the Generation of Heat

particular modification of this motion.
This was first started by Lord Bacon &
followed by Sr Isaac Newton who sayin
a Query at the End of his Opticks that
Light, and Gross matter are mutually con-
verted into each Other.
The 2.nd Opinion is that Fire depends
upon motion, but that this motion can
be obtained only in the particular species
of matter contained more or less in all
Bodies. This is followed by some Foreign
Philosophers.
By the 3.d Hypothesis Fire is supposed to
depend upon motion peculiar to the

Of the Generation of Heat

Subtile Elastic Fluid Alone, w^ch^ we called formerly the Newtonian Ether. This is the Opinion most generally received, & w^ch^ seems to be best confirmed by the Experiments relating to y^e^ Mechanical production of Heat by Attrition.

II^nd^ Of Percussion. This is y^e^ Second Mechanical Means of producing Heat, by w^ch^ is meant chiefly hammering. It is for the most part applicable only to Metals. Stones, Semimetals, & Hard Woods not admitting it upon y^e^ Acc^t^ of y^e^ Friability & Weakness of Texture.

For the production of Heat by percussion

of the Generation of Heat

Two things are necessary 1: a firmness of Cohesion in opposition to Fluidity or Friability. 2nd: a quick Repetition of the Stroke. Thus Iron may be hammered till it is red hot. ——

That the Body to be heated must be fixed in this Case, as well as in y^e Case of Attrition appears from several Circumstances. E.G. the Striking Hammer being moveable is almost cold, tho' a piece of Iron be beaten with it on an Anvil till it is almost red hot. Again when a Nail is driven up to the Head in a piece of wood, so that it can be forced no further, a few Strokes will render it

very hot; whereas many Strokes will not have the same Effect while it continues to move.

From all y^e^ has hundd^s^ given upon this Head, it appears that y^e^ Heat generated by Percussion is owing to a Tremor or Oscillation excited.

III^d^ of Collision. This is the third Mechanical Means for generating Heat. I shall attempt an Explanation of this, Tho' it is an extremely difficult task. Collision is a slight Stroke of two Bodies Ag^st^ each other, chiefly of M^r^ Stones & Crystalline Substances, not as being better adapted for it by any particular

Of the Generation of Heat

Quality in consequence of their Mixture,
for Argillaceous Earths may be sufficiently
hardned by Art to produce the same Effects.
It is surprising to see the Degree of Heat
produced by so slight an Impulse. it has
being sufficient to fuse even Iron w.: is
among the Bodies of the most difficult
Fusion. nothing is more difficult
to explain than this Phenomenon in
the whole Theory of Fire. we shall however
Observe 1.: that every Stroke a small
particle of the Body flies off. This does not
happen from the Force of 1.: Stroke, but
from the Elastic Fluid accumulated at

Of the Generation of Heat

Heat please w:ch by its expansive force throws off the particle. Something like this happens in Bologne Bottles w:ch are made without Annealing. for if a Bullet be dropped into any one of these, it will not fracture it. but if a peice of Glass or any such Angular sharp substances be employed, the Bottle will be immediately shivered to peices.

The ready Breaking of thick glass vessels upon the sudden Application of Fire cannot be accounted for, but by the Accumulation & Expansion of the subtile Ether as in the former Case.

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The Inference drawn from my foregoing Experiment relating to Glass may be further illustrated by recollecting that Glass bubbles are able to bear a very considerable pressure & which may be broken to pieces by a very slight stroke. And upon the whole tho' as I said before it is extremely difficult to deliver any thing complete upon the Subject of Collision, yet one may be observed to confirm a belief of our general Proposition "that there is an Elastic Fluid in all Bodies more or less according to their State of Aggregation,

Of the Generation of Heat

"and that by exciting Tremor or Oscil-
-lation in this Fluid, all mechanical
Generation of Heat depends".

Fire being already considered as
produced by Mechanical Means, is now
to be treated as generated by y^e Mix-
-ture or Combination of various Bodies.
Here the chief Difficulty in y^e Theory of Dr
arises: for in Cases of mixture y^e Heat
does not seem to depend upon motion, but
on the different properties of y^e Substances
to be combined.

Before we proceed to particulars, it
will be necessary to lay down a few
general propositions.

Of the Generation of Heat

1st: All Chemical Combinations pro-
duce either Heat or Cold greater than
either Body contained before mixture.
we must however observe 1st: the Degree
of Heat or Cold cannot be always ascer-
tained. for as the Change of Temperature
in Bodies, is encreased proportionably to
the Quickness, & some other Circum-
stances of the Union; so when these
Circumstances are any way abated, the
Change of Temperature becomes in pro-
portion less obvious to our Senses. thus
in the Solution of Selenitic Salt in water

Of the Generation of Heat

Only a few Grains are dissolved in a Pint; & a considerably time is required for performing even this Solution. It is a very necessary tho' laborious Task to enumerate all such Combinations. Many have attempted this, & have enumerated prodigious Numbers of Mixtures. M.r Musschenbroek for Instance reckons more than 300. & upon y.e same Plan w.ch he followed he might have reckoned several hundred more. This superfluity arises from an Ignorance of a proper Chemical System. I have made the following Table upon a

Of the Generation of Heat

different plan. Tho' I will not pretend to say are faultless: but only y: they render this part of the Subject less intricate to the Learner, tho' y: perplexing number of Combinations enumerated in some Tables.

I shall first give You a Table of the heating, & then of y: cooling Mixtures, & after each a few general Remarks on the several Articles. —

Table of the Heating Mixtures.

I Acids w: Alkalies

— with Neutrals containing Or

— with Soap & Hepar Sulphuris

Metallic & Earthy Salts w Soap & Hepr Sulphuris

Sulphur with Alkalies

Ammon: Salts w: fixt Alkalies

Metallic Salts w: fixt Alkalies.

Ammon: Metallic & Earthy Salts w: Neutrals.

II Acids w Oils.

— w: Animal & Veg: Bodies

Ammon: Metal: & Earthy Salts w: Oils & oily Bodies.

III Acids with Alkochol

Metallic Solutions w Alkohol & Attract & Acid.

IV. Acids w: Metallics

— w Metallic Salts

Sulphur w: Metallics.

Neutrals w: Metallic Salts.

Table of the heating mixtures.

Ammon: Metallic & Earthy Salts w: th Metallics.

V. Acids w: th Earths.
— w: th Earthy Salts.
— w: th Animal & Vegitable Substances.
Sulphur w: th Earths
Ammon: Metallic & Earthy Salts w: th Earths.

VI Acids w: th water & watery Liquors.
— w: th Animal & Veg: Substances.
— w: th Air.
— wine w: th Water
Metallic Solutions w: th water & precipates them.

VII. Acids w: th Acids.

VIII. Alkalies w: th Inflammables.

IX. Alkalies w: th Metallics.

X. Alchohol w: th Veg: ♃.

XI Alchohol w: th water & watery Liquors.
— w: th Animal & Veg: Substances.
— w: th Solutions of Salt.

Table of heating mixtures.

XII. Mercury th w: metallics.
XIII. Metallics th w: metallics.
XIV. water th w: Calcined Salts.
—— th w: dilaquescent Salts.

Remarks on the Table.

article I
vol: Alkali has been long thot to ge-
=nerate cold th w: Acids: but later Experience
proves the contrary. for if thrown into wa-
=ter it generates Cold. th w: concentrated
Acids it generates Heat. now if the
Acid employed be very dilute, the cold
generated by the water th w: it contains may
be greater than the Heat generated by the
Acid, or they may be so proportioned as
precisely to counteract each others Effects.

Remarks on y^e heating mixtures.

by that means produce no Change of Temperature on the Addition of the Alkali, & hence the Foundation of this erroneous Ancient Opinion. if the Alkal: is in a caustic State more Heat will be generated than if it was mild. the other Heads of this and indeed of all the other Articles do not produce their Effects except when a Combination takes place.

Article III. This is properly made a Separate Article, for tho' some Adduce y^e Alcoholic a Composition of Oil & water, yet the Oil does not exist formally in it, and y^e Heat generated is greater than that of Acid & simple water. H^a W:

Remarks on 2d & 4th Table of Heat & Frig.

Artic: 2d VI. The water must here be supposed in a State of Fluidity.

Article VII. It is rather doubtful whether the Heat here produced depends upon the Action of Acids on each other, or on the water which they contain. I think the former the most probable Supposition, because a tertium Quid is produced, & the Heat generated is greater than 2d & 4th: small Quantity of water contained in concentrated Acid could be able to produce.

We shall now proceed to the Table of cooling Mixtures. —

Table of cooling mixtures

1 Acids w.th Bodies exhaling much vapour

2 water w.th Crystalline Salts

—— with Ice.

3 Ice w.th Saline Bodies.

4 Ice with Alchohol.

5 Alchohol w.th Ammoniac Salts.

6 Alchohol w.th Oil.

7 Oils with Oils.

8 Alchohol w.th Soap & Hepar Sulphuris

Of the Generation of Cold

Remarks on 4th Table of Cooling Mixt.s

Article 1st Acids applied to vol: Alkali generate heat. but the Inhalations of Acids arise from the Addition to this Alkali in a compound State overcome by this Cold the Heat otherwise generated.

Art: 2nd The Combination of Ice and water is extremely curious. for if the water be heated to 50° & the Ice at 32° the Thermom.r will sink to 32° during the Solution.

Article 5th perhaps this Article might have comprehended with propriety all the Crystalline & Deliquescent Salts.

After this general view of 4th heating

& cooling Mixtures, it will not be improper to add some general Observations thereon. in the first place these Tables contain all y^e Chemical Combinations in w^ch any Change of Temperature can be observed.

In the Combination of Earths & Metals the Change of Temperature cannot be observed, because a very intense Heat is required to unite them. the Generation of Heat always happening upon these Chemical Mixtures is extremely difficult to be precisely determined. it chiefly depends upon y^e proportion of y^e Matters

Of the Generation of Heat

added. Thus Sal Armon^{c}: may be dissolved in water in the proportion of One to three, and if less of the Salt is employed a proportionably less Degree of Cold will be produced. Heat is most effectually & most plentifully produced when the Mixture is done at Once, & not at several Intervals, & hence the means of expeding the Union of Bodies are to be employed when we would obtain the greatest Heat: as for Instance in performing y^{e} Mixture in Open Air or in Vacuo, as ceding as it takes place more readily in One than the Other.

To obtain the greatest Degree of Cold

Of the Generation of Cold

Let a superabundant proportion be employed of the Body producing Cold. - Here a Question arises whether by combining a large or small Quantity, more Heat or Cold is produced than is proportionable to the Quantities added? For my own part I can find no great Difference ~~to~~ because the Heat or Cold communicated to the whole Bulk is in proportion to the Quantity required. we may sometimes perhaps observe more Heat or Cold in a large Quantity: but this happens

of the Generation of Heat & Cold.

Because such Bodies are a longer time time in acquiring & losing Heat than smaller. Heat & Cold produced in a way of mixture encrease in a certain pro:=portion whatever may have been their Temperatures before Mixture. thus ⊕r and fixt Alk: generate by mixture 100:° of heat more than Ordinary, so y:^e if they were heated to 40:° before Mixture, they would on being united produce 140:° if to 60:° they w:^d produce 160° Degree of Heat, & so on in the same Ratio. this Observation is applicable to y:^e cooling

of the Generation of Heat

Mixtures. when a Body wch we desire to freze contains a considerable Degree of Heat, it is very difficult to reduce it to the freezing point, because the Mixture applied must be much below that point. thus if the freezing Mixt: be at 26°. wch is 6°. below the freezing point, and the Body to be congealed be at 40°, no Freezing can be Obtained, for the intermediate Degree between these two Viz: 36°. is above the freezing point.

From considering this Subject it appears that the Notion of Caloric in

Of the Generation of Heat

and Frigorific particles is without
Foundation for these Effects do not
arise, or at least are not inseparable
from any peculiar Matter. The same
Bodies being capable under proper
Management of producing either
Heat or Cold by the same Operation.
- Thus Water poured upon calcined
Neutrals produces Heat & crystallizes
them; and if the Addition of Water
is still continued it produces Cold.

of the Generation of Heat.

Ice & water differ only in their State of Aggregation, & yet produce opposite Effects: nor can those Effects arise either from the Absence or presence of Phlogiston, since Acids and water Substances the most uninflammable produce Heat, while Alcohol & Oil &c. are remarkably inflammable produce Cold. even when Phlogiston is present, & in some measure influence the mixture, the Heat or Cold produced are by no means proportionable to the Quantity

Of the Generation of Heat

Mercury. for Instance Heat produced by the Combination of Acids & Metals is equal to, or perhaps greater than that resulting from a Mixture of Acids and Oil. From w: has been said then Our Proposition will appear true " that the Change of Temperature indeed depends on the State of Aggregation"

Acids become the Basis of numerous heating Mixtures from their great affinity to Other Bodies. being almost

universal Menstrua. before we pro-
:ceed further it may not be improper
to constitute an Accurate Distinction
between Mixture & Solution. by Mix-
:ture the Substances loose their peculiar
properties, & form a tertium Quid. by
Solution the Substances possess y^e same
properties as before except y^t they
are changed in their Form of Aggre-
:gation. thus Alkali thrown into
water is changed in its Texture and

Of the Generation of Heat

reduced to a fluid State. still however retaining its particular Qualities; but if joined w.: 2d w.: and the properties of both become entirely changed, & a Neutral will be produced differing in Quality from either. Miniature takes place in a certain proportion of 4 Ingredients, beyond w.: either may be added without 4: Effect of Miniature; tho' by adding a sufficient quantity of 4 Solvend a Solution may be Obtained. in Miniature only two Ingredients, in Miniature

many may be combined at y^e^ same time. in some cases of Miature this Observation may appear not true. E.g.: It may be objected that the three Ingredients Acid, Phlogiston & Alkali are required for y^e^ production of Hepar Sulphuris, but then let it be Observed that y^e^ Acid & Phlogiston must be united before a Sulphur can be formed, w^ch^ afterwards uniting w^th^ y^e^ Alkali produces a Hepar. Indeed if y^e^ Objection takes place here, it may also

Of the Generation of Heat

be admitted Agt. every Combination.
for in none of them are pure Elements
parts employed. There is also a consider-
rable Difference between Solution and
Mixture in their Decomposition. For
in Order to decompose Bodies combined
by Mixture, greater Heat is requisite
than wd. have volatilized them in a
seperate State. Whereas if Bodies are
united only by Solution, that Degree of
Heat wch. would volatilize them in a Se-
perate State, would also volatilize ym.

Of the Generation of Heat

from when ~~separate~~ dissolved. Thus from a Solution of Neutrals 2d y: superfluous water may be readily exhaled, while an Intense Heat is required for the Dissipation of that portion necessary to Crystallization. upon the whole I think we may conclude y: when mixture takes place Heat is generated, when Solution Cold. these Cases in w: Heat & Cold both happen will be readily understood from an attentive Consideration of y 2d foregoing

Of the Generation of Heat

Tables. we may also conclude y^t in
these Cases Heat is produced by Motion
as in the Mechanical Generation.
much however depends upon y^e Manage-
ment of the Air 1^o. Cold may be produced
by the Rarefaction of y^e Air as we may
prove by the Air-pump. 2^do. Cold may
be produced in Bodies by restoring their
fixt Air to an Elastic State. & 3^o. Cold
may be produced by converting Bodies
into Vapour.

These Experiments are very useful.
would be more so if the Convenes of them

could be exhibited: but this can be done in the first Instance only, in which an Increase of Heat may be perceived by restoring Air to an exhausted Receiver, or Again Acids or Alchohol combined with water shew an Increase of Heat & a Diminution of Bulk from Condensation. we may Observe by way of Illustration to this Subject, that as an Elastic Cord when it receives a Stroke, has quicker vibrations according to the Increase of Tension;

Of the Generation of Heat

so in Heat occasioned by y^e Undulations of an Elastic Fluid, the vibrations will be fewer in proportion to y^e Diminution of Density in that Fluid by the Rarefaction of the Air, & consequently a Generation of Cold may be effected.

We are now to consider y^e Generation of Heat by means of Fermentation.

By Fermentation is here meant every kind of Assimilating process in all these Heat is visibly produced, but more especially in the three most noted

Of the Generation of Heat

Spirits, the Vinous, Acetous & putre-
-factive. in the last of which so great
Heat may be produced as to excite actu-
-al Flame. in the Acetous y^e^ Heat gen-
-erated is less. & in the Vinous least of
all.

Philosophers in general think Heat
is generated in Fermentation by Me-
-chanical Means: but they are
certainly mistaken, if we admit y^e^
supposition that Heat is not to be produ-
-ced by the motion of y^e^ Particles of
Fluids Against Each Other. Besides y^e^

Of the generation of Heat

Heat generated is not proportionable to the intestine motion. For in the vinous Fermentation there is y^e greatest motion, and least Degree of Heat, Whereas in the Nitrefactive there is y^e greatest Heat, and least motion. I am inclined to think from all these Phaenomena that the Heat in Fermentation depends upon a Decomposition & new Combination. but the whole Theory of Fermentation is so imperfect that we can deliver nothing w^th Certainty upon it. —

Of the Generation of Heat

we next proceed to consider y^e^ Generation of Heat in Animal Bodies. a subject of great Importance, but extreme-ly difficult to be treated in a proper manner. Heat is observed to be greatest in breathing Animals, and of those greatest in such as breath frequently very small Insects may likewise be observed to have some Heat by apply-ing a Thermometer to a number of them together. in the same Class of Animals Coteris paribus the Heat is nearly the same. thus in the human Species it is

Of the Generation of Heat in Anim: Bodies

generally between 90: & 100: .

It is very difficult to investigate the causes of Animal Heat. For this purpose Authors have formed various Hypothesis, the chief of which I shall enumerate.

1: Animal Heat is supposed to depend upon Fermentation, particularly of the putrefactive kind. That this Fermentation generates heat is beyond a Doubt. nay it is as certain as y: such a Fermentation occurr in y Animal Body: yet these circumstances how=ever

favourable to this Hypothesis are by no means sufficient to overcome the Objections that may be raised against it: For 1st we may Observe that the Putrefaction in living Animals never rises so high as to produce the Heat we Observe in them. It may also be added that tho' Fermentation may produce considerable Heat in Animal Bodies; yet this only happens when it is advanced so far as to destroy the Texture of the Body. This Putrefaction is

Vol

# of Animal Heat

is sometimes observed in Animal Fluids, tho never except in a morbid State.

2d. Objection is, that Heat produced by Putrefaction is so slow, that it is lost as soon as generated. Some indeed imagin that the putrefaction tho slow is constantly kept up by the Food taken in: but I think y: such Aliment as we take in, is often Antiseptic, wch. according to this Hypothesis shd. tend to the Diminution of Animal

# of Animal Heat

Heat.

a 3: and a very strong Objection is y: in Instrument Mapric y: Heat is in Proportion to the Quantity of Matter, Whereas we find that in Animals of y: same Order the Heat is nearly equal tho' they differ considerably in Bulk. for Instance we find y: y Heat of a Mouse, is as great as that of an Elephant.

These Objections alone seem sufficient to prove the Fallacy of this Hypothesis. Tho' we might add further that y Heat of animal Bodies is not Proportionable

# of Animal Heat

to the Degree of Putrefaction: in putrid Fevers the heat is not so great as in some of the inflamatory kinds nay it is sometimes below y^e^ natural standard. The same may be observed in the Scurvy; for when this Disorder is so violent as entirely to corrupt y^e^ animal Fluids, the Heat is lower than in many other Cases. Besides y^e^ Heat of putrescent Matters cannot be encreased by extraneous Motion w^ch^ we see happen in Animal Bodies: but is rather affected in a contrary Manner.

of Animal Heat

4th a still more conclusive Objection is that Animal Bodies putrefy most quickly when all the vital Functions cease, and yet notwithstanding y^e great Degree of Heat produced here, the Corpse will be very little hotter than y^e surrounding Atmosphere. I think we may therefore safely conclude y^t Animal Heat is not the Effect of Putrefaction.

a Second Opinion is that Animal Heat depends upon certain Decompositions & new Combinations going forward in the Body during Sanguification: but in

# of Animal Heat

this Case the Heat will be proportionable to the Quantity of Food, & the Excretions performed; and that this is not y Case appears from such Animals as sleep half the Year; for in these y Heat remains nearly the same during y sleeping Season, tho' they not receive any Aliment & consequently cannot be supposed to loose much by Excretion. if there is a Deminution of Heat in these Animals, or in a Man who fasts for several days, it is owing probably to a want of Exercise. a 3rd more specious & more generally

Of Animal Heat

received Opinions y^{t}: Animal Heat depends on Motion excited by Mechan^{l}: Means. That it depends chiefly upon Motion appears evident from y^{e} Dimi-nution or Increase of heat on y^{e} slower or quicker Motion of the Blood. & to demon-strate in w^{ch} manner Motion produces this Effect, various Hypotheses have been proposed. we have already endeavoured to prove the Absurdity of supposing y^{t} Animal Heat is owing to an Intestine or Fermentative Motion of the Fluids. I think the Opinion of those who attribute

# of Animal Heat

it to the action of the Fluids &c. Each
other will appear equally groundless
from the following Fact. if Blood be
received from the Body in a Vessel con-
taining a Fluid equally warm, by the
most violent Agitation &c. Miatures
will not receive any additional Heat,
but in a short time become cold.
It is more generally alledged &c. Heat
is owing to the Attrition of the Fluids &c.
the Solids. This Opinion is easily confuted,
for to the Generation of Heat by Friction,
the Surfaces must both be uneven, nor

should there be a Fluid interposed be-
=tween them, the Reverse of wch hap-
=pens in the Animal Body. Besides
Neither of the Bodies are fired, conse-
=quently little or no Heat can be gene-
=rated. Finally the Fluids do not
move wth sufficient Velocity to produce
Heat. This is ye Argumentum fun-
=eris wch many have endeavoured to
elude. Some suppose that ye Increase
of Surface compensates ye Diminution
of Velocity, & upon this D. Martin
founds his more ingenious, than

of Animal Heat

useful Treatise. but allowing y^e^ Diva-
riation, w^ch^ y^t^ Gentlemen mentions
to be equal & proportionable to the Di-
minution of Velocity in y^e^ small vessels,
yet his System may be overthrown
by the following Observations alone
viz: 1. That in vessels of y^t^ same size
near the Heart, and in y^t^ remote Ex-
tremities, the Blood moves w^th^ very
different velocities. The Motion of y^e^ Blood
thro the Lungs being to y^t^ of y^e^ Aortic
System as 5 to 1 nearly; & thro in
different parts of the Body y^e^ Heat

may vary, yet upon y: Wholesomy: Quickness of Circulation it will be soon nearly equal. Some other Cause must therefore be invented to acc: for acc: Heat.

Dr Rob: Douglas Sanctions y: That is only produced in its passage thro y: Capillary Vessels, or such as will only admit one Globule to pass at once — Agt: This many Objections may be brought. he thinks that in such a Case the Vessel & Globule would act on each other as Solids: But he does

# of Animal Heat

not properly distinguish Friction from Adhesion. With the Bodies being smooth when Applied may have considerable Adhesion, but no Friction, this requiring a Roughness, consequently therefore no Heat can be produced by this means. we may add further than y^e^ Velocity of the Moving Particles, Absolutely necessary to the production of Heat, is here wanted, for the Blood in these Vessels, as Dr Hales has fully proved by Experiment has an extremely languid Motion.

Let us now consider y^e^ Hypothesis by which y^e^ Heat of Animals is supposed

to depend upon the motion of the Blood thro the Lungs. the Momentum here has been already given by w.ch it appears that want of velocity cannot be objected. — Those Who endeavour to explode the Opinion use another Argument viz: that Heat is greatest in Breathing Animals whose Lungs are constantly exposed to the cool Air in Respiration. this Reasoning I shall not attempt to deny totally, tho I imagine y.e Breathing is chiefly designed to obviate y.e Disadvantages y.t might arise from too great Heat otherwise produced in those Animals, and as a

# of Animal Heat

proof of this I alledge that ye Air w:ch escapes by Inspiration is much hotter than that taken in by Inspiration. Besides we have no Experiments to prove that Heat is either generated or diminished in the the Lungs. for Blood drawn before or after passing thro' ye Lungs is equally warm. if by any Experiments a Difference can be observed between the Heat of Venous & Arterious Blood, it happens because ye latter flows out more quickly, & thereby looses less Heat than the former. upon the

whole, I suspect this Theory has but very little Foundation.

Dr. Bryan Robinson imagined y^t Heat was occasioned by Something (perhaps he meant an Acid) Absorbed from the Air by Animals, & mingled w^th the Blood of the Lungs. I differ from him in Opinion rather supposing that Something is rejected from, than taken into y^e Lungs during Respiration.

all those Hypothesis being mention'd & the Objections to each, I think

of Animal Heat

none of them appear satisfactory. I shall therefore deliver a few Observations wh. I do not presume to offer as unexceptionable, but shall submit them to the animadversions of any candid Inquirer. it may have its use, at least there is no Danger in starting such an Hypothesis, y Truth of which is to be examined by Experim.

As Animal Heat evidently depends upon, or is principally connected wh. the Moving Powers of the System, so those powers are dependt

on a subtile Elastic Fluid or Nervous Power, conveyed to every moving Fibre by hollow Tubes or Nerves; & in this Fluid, Oscillations are constantly excited. The Existence of this Nervous Fluid after long Disputes among Physiol is now generally admitted. It is of such a Nature as proves it cannot be derived from Secretions, & from the great Subtility & Elasticity of its Nature, it may probably have a near affinity to the Electric Fluid. I am far from

# of Animal Heat

Nourishing they are the same. For tho' a subtile Elastic Fluid may be y^e Foundation of Fire, Light, Electricity and Animal Heat; yet we must consider it as very differently modified in each of these. I shall not pretend to conjecture in w^ch manner these Modifications are performed. It is enough for our present purpose to say y^t such a Fluid is diffused thro every Fibre of the Animal Body, & that from an Undulatory Motion continually excited

excited in this Fluid, Animal Heat is probably derived. I do not offer this Opinion as a real Truth, nor am I prepared to answer all y^e Objections that may be made ag^st it. I only offer it as an Hypothesis, w^ch not being entirely void of probability may be a Subject of further Experiments and Observation.

We come now to the 5^th means of generating Heat viz by Inflammation. This is commonly

Of the Generation of Heat.

Not to be an Instance of Communication, but improperly, because the propagated Heat becomes greater than in y^{e} Body whence the Inflammation began at first, and the Heat in this last Body is not diminished by this means. in Consequence of Inflam^{n} a new motion is excited, and every particle or Spark of the inflamed Body becomes as it were a new Centre of Oscillations in each of which a motion is also excited in every Direction. in these Cases only does the Phlogiston of y^{e} Chemists to

of Inflammation

appear necessary to the production of
Heat. Inflammation depends upon
a peculiar affection of this, or upon its
being converted into vapour. The
Other tho so readily inflammable
may have a burning Coal plunged
into it without being inflamed, whe-
-as if the Coal be held in the vapour
arising from the Other, it will imedi-
-ately set it on Fire, the subtile Fluid
which (to take an Example from a Spring
coiled up) being then let loose. we
may now I think Discover the Safety

of Inflamation

That the Collision of two Elastic Fluids is absolutely necessary to the Inflammation of those Fluids. Phlogiston must be one, and Air is generally the other. but so far as we are capable of Judging, the Phlogiston being being any other Fluid will act w: it so as to produce Inflam: -mation. for Example water converted into Vapour will answer this purpose. — the Action of the Air I shall consider more fully hereafter. Bodies may be inflamed by the Action of the Air

without immediate application of burning Fewel. This appears evidently in Sulphur evidently heated, or in Oils, but more especially in y^e^ burning Phosphori.

Certain Bodies are liable to, and Others incapable of Inflammation. Therefore it must require a peculiar matter. Here a Question arises whether Inflammation depends upon Bodies as Mixts, or whether it is essential to some Elementary Bodies? — I rather favour the former Supposition, because

# of Inflammation

we know y: in every Inflam^{n}: an Acid is present, w^{ch}: is not inflammable as Oil. Sulphur. Alchohol &c. here must then be Some other matter requisite this the Chemists call Phlogiston, and they imagin it is an Elementary matter of itself Inflammable. here however I differ from them, for the Acid seems to have as great a Share in the Inflam^{n}: as the Phlogiston. This Phlogiston then of the Chemists I conceive to be the Nitrious Air, which we find arises from all inflamed Bodies, & enters

sometimes into their Composition,
as in the vinous Fermentation. In-
=flammation seems to consist in
the Resolution of this Compound in
the Air; may be necessary is Air that
every individual particle must bee-
=pose thereto. on this principle alone
can we acct for the Effects of y^e Blow-
=pipe. Common Air therefore is
Absolutely necessary to Inflammation,
that is for the Resolution of Phlogiston
which it does chiefly by Attracting-

# of Inflammation

uniting w:^ch and destroying y^e pecu=
=liar properties of its Mephitic Air. this
Mixture however like all Others is limited:
and w:^n ever more is added of either will
be kept in Solution, & consequently will
not loose its peculiar Properties. hence
it is evident if any means can be in=
=vented for Attracting y^e Mephitic
Air more strongly than y^e Surround:^g
Atmosphere, a less Quantity of common
Air would suffice, by the Assistance of
such means for a given length of time,
for the purposes of Respiration & Inflam:^n

# of Inflammation

This means was invented by D.r Hales. he found that y.e same Quantity of Air which served an Animal to breath for two Minutes, would serve y.e same Animal eight or ten minutes by y.e Interposition of Cloths dipped in Caustic fixt Alkali, w.ch has a very strong Attraction to fixt Air.

Phlogiston therefore is a Miat composed of Mephitic Air, and an Acid, w.ch by Inflammable, is resolved or decomposed. it acts chiefly by means of the common Air which Absorbs y.e fixt Air.

of Inflamation

for if this was not the Case we shou'd see the Effects of Mephitic Air either in extinguishing Flame, or destroying animal Life.

Inflam^{n}: is universally situated in the Vapour of Bodies. E.g: if a Candle be extinguished, & brot near to a burning Body, the Flame will be again renewed, tho the Bodies be kept at some Distance from each other. Here also is the Exp^{t}: applicable^{ch}: we lately cited, of plunging a burning Coal

into Other. on these principles are
founded the Machines for extinguish:
=ing Fire — they contain a small
Cask of Gunn: powder w: is againen:
=closed in a Cask of water. when the
powder explodes, the force of it blows
out the Flame, & at the same time dis=
=perses the water w: prevents y Fire from
being imediately rekindled. From w:
has been said it appears that y Subjat
of Inflamation is a vapour arising

of Inflamation

from certain Bodies; that this Vapour must be raised before Inflammation can take place — that this Vapour is the Phlogiston of the Chemists com: posed of an Acid & Mephitic Air. — y: Inflam: consists in the Resolution of this Phlogiston & the Absorption of y Mephitic Air by y: surrounding Atmosphere; and upon this whole we may conclude y: Inflam: is an Instance of the Generation of Heat by Combination or Mixture. That the Mephitic Air here

mentioned is a part of the Phlogiston appear from its Effects. The Air is not so very obvious. yet it may be demonstrated in some Cases. particularly of the burning Phosphori wch we have all an Air for their Basis.

This is all I think necessary to be said upon the Subject of Heat generated by Inflamation. Something however still remains to be said concerning the production of Light, wch may be considered as a different Modification of the

Of Light

same Matter that produces Heat, &
indeed is has such a near affinity to it,
that they may both be comprehended
under the Term Fire. I shall not deli-
ver more upon the Subject than an
Enumeration of its several Divisions.
To the 1st Division we may reduce such
Bodies as become luminous by being
exposed to the Light of Others. Such after
being in the Light a few Minutes will
afterwards dispense Light themselves for
several hours. in accounting for this

# of Light

Some Suppose y: such Bodies Absorb
Light: but this Opinion is Open to
innumerable Objections. perhaps
Vibrations are excited in them w: remain
after the exciting Cause is removed. of
this kind are many Substances in Na-
ture 1st the Bologna-Stone w: was dis-
covered by an Alchemi-Philosophico
Shoemaker, & found to be nothing but a
Combination of Vitriolic Acid & Calc: Earth
— 2nd a German Lawyer discovered a Phos-
phorus in dissolving Chalk in Nitrous
Acid,

Of Light

and afterwards calcining it. this from the Inventor was called Phosphorus of Baloccin. all kinds of precious Stones particularly the Diamond exhibit this Phanomenon in a greater or lesser Degree. —

The 2nd: Division to be considered comprehends the luminous Animals, as Glow worms, - Moths - Insects in Sea water &c.

Under the 3d: Division may be reckoned the production of Light by Putrefaction as in Fish, wood &c. but this perhaps will

be found to depend upon Facts.

Under the 4th: Division we may reckon the production of Light from Electricity, a Subject so difficult and Obscure y: the greatest Geniuses of the Age have not been able to investigate it clearly.

The 5th: Division comprehends the Light produced by Mercury in Vacuo. This perhaps is only a Species of the Electric Light. I must Observe that this Experiment will not succeed if y: Vacuum is very perfect.

I do not chuse to enter further upon

Of Light

this Subject of the Production of Light.
I only point it out for your future
Inquiries. Nor shall I here discuss whe-
ther Light is a peculiar Matter issuing
from the luminous Body, or only a par-
ticular Modification of the Æther: y:
is so generally diffused thro nature,
but I shall hasten to y: next part of
our work after concluding from w:
has been said, that Heat consisting in y:
motion of a particular Matter w: is
present in all Bodies, but does not form

Of the Communication of Heat

a part of their Mass as Mixts.

This part of our Subject tho' y^e most interesting & most connected w^th practice has hitherto been least cultivated. in treating upon it I shall endeavour to lay down a general Enumeration of the different Laws which take place in y^e Communication of Heat, sometimes adding a few Remarks.

Law 1^st The Communication of Heat is common to all Bodies, & all Bodies

Of the Communication of Heat

will impart & receive Heat from all other Bodies: and this Communication of Heat will continue 'till all surrounding Bodies attain the same Degree of Heat.

Remark. This shows $\frac{e}{q}$: expansive power of Fire, $\frac{ch}{w}$: is always endeavouring to recede from its Center. $\frac{e}{q}$: Action of $\frac{e}{q}$: Sun is the most general Source of Heat from whence Supplies are derived for the Loss of that which is constantly flying off. Heat every where exerts a repulsive & expansive power, without shewing

any tendency to be attracted by particular Bodies. As a Consequence of the Equality of Heat in all Bodies it appears that Fire is common to all Bodies, but peculiar to none; & that if in different Bodies different Degrees of Heat be observed, this Variety is owing to the Difference of Vibration excited in such Bodies.

——— II.nd — The Communication of Heat between two Bodies requires some time, & diff.t times are required

of the communication of Heat

in different Bodies.

III°: The Quantity of Heat lost or rec:
in a given time is directly as the Quantity
of Heat in the communicating, &
inversely as the Quantity in the receiving
Body. Thus, if a Body heated to 30°: be
applied to one Body at 100°: & another
at 200°: the heat lost or received will be
greatest in the last case. Again if the
Body at thirty be raised to 60°: the
Heat communicated in a given time
will be greater when it is at 30°: than at
60°: & vice versa. —

of the Communication of Heat

Law IV: the Bulk of the Body, and the Quantity & Quality of y^e^ Matter being given, the Heat lost or received will be proportionable to y^e^ Surface. — Hence it follows that y^e^ Figure of Bodies has considerable weight in these Cases. E.G. a given Quantity of Matter will communicate or receive more Heat in the Form of a Cube than if it be moulded into y^e^ Form of a Sphere.

V. — The Figure, Quality & Quantity

of the Communication of Heat

of Bodies being given, the Heat both received will be somewhat proportional to their Bulks.

Remark. If we suppose an Iron Ball to consist of a number of concentric Layers, Heat communicated to it will will pass slower, & slower ~~it~~ from One Layer to another towards y^{e} Center. Whereas in returning from y^{e} Center again to the Circumference of y^{e} Ball, its motion will be performed in a less time, as it passes from One Layer to the greater which surrounds it.

Of the Communication of Heat

Law VI. Heat passes out of any Body in the y^{e} greatest proportion at y^{e} part where the Layers are fewest.

— VII. The Surfaces & Bulk of Bodies being given, they lose or receive Heat in proportion to the particular Densi: -ties of their Matter.

Remark. Muschenbroeck supposes y^{t} this depends upon the Density of y^{e} Bodies, & has constructed a Table on this Suppos: -tion. But here y^{t} great Philosopher is certainly mistaken: for Mercury which

Of the Communication of Heat

is a Body remarkably dense grow hot and hot much sooner than water. to w: Whim ought we attribute it? – It depends perhaps upon some particular Quality not yet investigated or explained. These Facts lead us to observe that there are Conductors of Heat, and non Conductors of it as well as of Electricity, tho not so Absolute in the former as in the latter Case. But sufficient Examinations have not been made to determine the

of y^e Comunication of Heat

Qualities of those, or their exact Effects.
It may be even made a Query Whe-
-ther Air or Water grow hot or cold soo-
-ner? I imagin however y^t y^e latter
receives Heat most readily, because
a heated Body cools sooner in water
than in Air. It is observed y^t all
Fluids & Metals are quick Conductors
of Heat, as well as of Electricity. Wood
conducts Heat very slowly. hence y^e use of
wooden Handles to Instruments y^t
are often applied to the Fire. —

of the Communication of Heat

If there is any Absolute Non-Conductor of Heat, it is Air: for I think it is doubtful whether Heat is conveyed thro' the Air, otherwise than by y^e^ heterogeneous particles y^t^ are always diffused therein.

Another Analogy between y^e^ Heat & Electricity is Wool. This Substance does not convey Electric Matter, & conveys Heat or Cold but very slowly. hence its use in Lamp Furnaces to confine the Heat, & hence its use in Cloathing. & hence y^e^ Reason why metals feel

coolest to us than Wood tho' both be in the same Temperature may be discovered viz: that the former convey the Heat from our Bodies much quicker that the latter.

When Bodies receive Heat on their Surfaces farter than they communicate it thro their Substance an Accumulation may occur greater than $\frac{a}{y}$: Heat of the communicating Body; thus $\frac{a}{y}$ small with of a Lamp may very considerably heat a large Vessel. This Accumulation however is limited: for when the Heat

Of the Communication of Heat

flying off from y^e^ Surface of y^e^ receiving Body, is equal to that received from the ~~received~~ from the communicating Body. any further Increase of Heat ceases. Bodies cool faster in y^e^ Air than they otherwise would do, because there is a continual Change of Air on thier Surface, occasioned by the Rarefaction of the Air contiguous to, & the greater Density of that at some Distance from y^e^ burning Body. we may therefore conclude y^t^ Air is no more a Conductor of Heat than of Electric Aether. Water collected in

Large Masses preserves nearly y^e^ same Temperature in very great Changes of the Air. and this also chiefly depends upon the Force of Gravity, for when the water on the Surface comes condensed by the Cold it sinks & is succeeded by a warmer portion: this being acted upon by the Cold sinks likewise, while warmer water again supplies its place. by this means it happens y^t^ some of our very deep Lakes elude as it were y^e^ greatest freezing power we ever feel in this Climate.

43 *Of the Communication of Heat*

In the Earth & Ocean likewise $\frac{c}{y}$ Temperature is nearly $\frac{c}{y}$ same in all Climates & in all Seasons if we go to a certain Depth below the Surface. to determine therefore the Heat or Cold that prevail in any part of the Earth, we must not only consider $\frac{c}{y}$ Latitude of the place; but also the Distance of it from the Earth's Center & from the Sea Shore. Summers as they are moister, are always colder. Winters as they are moister are always warmer. Is not this owing to $\frac{c}{y}$ Disposition of moist Bodies to preserve their Temperature.

Of the Effects of Heat

I shall endeavour to pursue these Effects through their several Stages beginning w^th^ Expansion.

Expansion of Bodies is demonstrable in the lowest Degree of Heat w^ch^ we are acquainted: for we cannot reduce any Body in its utmost State of Condensation; therefore all Bodies are liable to Expansion. Bodies y^t^ are homogenious & of y^e^ same Structure are expanded every way equally by the power of Fire. Fluids generally suffer a greater Expansion from a

of Expansion

given Degree of Heat than Solids.
This Expansion is visible in many
Fluids, and upon this depends the Con-
=struction of very useful Instruments
called Thermometers.

As the proper Application of these
is often extremely useful in Medicine,
as well as in all the Branches of Ex-
=perimental Philosophy. I think it
will not be improper to enter into
a full Discussion of them, endeavou-
=ring at the same time to point out the

of Thermometers

Fallacies & Inaccuracy y^t^ may occur in Theirs or Structure.

of the Construction of Thermometers

For this purpose we choose Bodies that are most readily affected. or (as I shall call the Impression hereafter) most sensible of Heat. Such Bodies (as we have said before) are Fluids. There is one Disadvantage attending y^e^ use of these, namely that they will only measure Heat to a certain Degree, before they are converted

of Thermometers

into vapour. This Difficulty however is pretty well Abviated by the Calculation w^ch Sir Isaac Newton proposed.

The Fluids most generally employed are Air, Alchohol, Oil & Mercury.

Air has several Advantages as being very sensible of Heat and very expansive. But its Expansibility is so great, that it almost impossible w^th any Convenience to have a Scale long enó for measuring y^e Changes that occur in the Atmosphere.

It is also liable to be affected by the variation of Density in y^e^ Atmosphere. from w^h^ has been said therefore it appears y^t^ Air-Thermometers are only fit for transitory Experiments, and for such perhaps it is better adapted than any Thermometers yet invented.

Alchohol. When used for Thermometers is tinctured w^th^ Cochineal, that its motion in the Tube may be rendered more Ob-=servable. It is very sensible of Heat, & very expansible, nor will it freeze

of Thermometers

but in a great Degree of Cold, yet it will not shew great Degrees of Heat because its boiling point is considerably less than that of water. upon y^e^ whole however it may be employed w^th^ great advantage in many Experiments especially since it will not change by keeping for a very great number of years. —

Oil has often been used w^th^ tollerable Success for shewing the Changes of Temperature in the Air. For this purpose the expressed Oils of vegitables are

most suitable. Oil boils only in an intense Heat, nor will it freeze but in a great Degree of Cold. but then even a moderate Degree of Cold gives it such Viscidity as renders it entirely useless.

Mercury has more Advantages to recommend its use than any other fluid. — It is next to Air in Sensibility. it resists freezing more than any Fluid. it does not boil except in a very considerable Heat, but on the contrary

Of Thermometer

it is not very expansible, so that it will not require a very large Scale. and consequently will not shew accurately the small Changes of Temperature. It is liable to be rubbed into a black powder by its motion ag.st the Sides of the Tube; it will calcine before it arrives at its boiling point, Barely Sealing and stopping up the Tube. upon the whole it appears that a Mercurial Thermometer is the best to be used

as a Standard for shewing the Changes of the Atmosphere & for great Degrees of Cold, but should never be used for determining Heat greater than that of boiling water. —

The larger the Bulb of a Thermometer be in proportion to its Stem, the greater will the Scale be, & the Expansions more evident: but then as the Bulb becomes larger, its Sensibility becomes less. The Glass of which the Bulb is composed should be blown as thin as is consistent with its Safety. It would

of Thermometers

also be better to make it in y^e^ form of an Oblong or Oblate Spheroid, than in the form of a perfect Globe. Since by this means more of the Surface of the contained Fluid will be exposed to the action of Heat or Cold, & consequently (by Law 4:) more Heat or Cold will be received, that is y^e^ Sensibility will be increased.

On the Uniformity of y^e^ Cylindrical Tube depends in a good measure the perfection & Accuracy of the Instrument.

When the Fluid is put into y^e^ Tube, it ought to be as free as possible from

Air, least any of the Air separating should divide the Fluid in y^e Scale.

When the Tube is filled to a proper Heigth, we are generally directed to extract the Air, & then Seal the Tube Hermetically; but Mr. Wilson an ingenious Gentleman at Glasgow who makes y^e most perfect Mercurial Thermometers, says y^t the Air tho' left in the Tube does not sensibly counteract the Dilatation of the contained Fluid, and y^t the

of Thermometers

weight of the Air does not sensibly affect the Motion of the Fluid in the Tube.

of the Graduation of Thermometers

a Scale divided into any Number of equal parts may be applied to the Tube: but Unless in this Case some general Rule is to be followed, we cannot compare the Observations of Others w^th^ our Own. two Standard points have therefore been fixed on: viz: the Degree of Heat in boiling and

freezing water. The most easy and exact method of getting the freezing point is to put the Thermometer into melting Ice or Snow; for tho' y^e^ water may seem to be above y^e^ freezing point, yet as long as the Snow or Ice is dissolving so long is the water at the freezing point, & accordingly the liquor in the Tube depressed to that point. —

The boiling point of water ch^d^. be=termined at a middle State of y^e^ Atmo=sphere, when the Mercury in y^e^ Barometer stands at Inches 29,5; for when y^e^ weight of the Atmosphere is less, there is less

of the Graduation of Thermometers

Suppose on the boiling water, & y Li-
quor in the Tube will not rise to 212. wch
is the boiling point on Farenheits Scale
& vice versa. —

The Application

When we desire to ascertain very exactly
the Degree of Heat or Cold in any Body,
Care must be taken to apply the
Thermometer for some time y: all
possible Heat may be communicated
from the Body. Otherwise we shall be
often deceived. as for Instance, it
has long been a Desideratum to

Of the Application of Thermometers

determine the exact Degree of Heat in a healthy human Body. Fawnheit has marked it at 95°: Others at 98°. and an ingenious French Philosopher has lately inferred it 99°: it should be computed at 100°: or upwards. —

of Fluidity

Having said eno' on the Subject of Ex-
-pansion. I shall proceed to consider
the next Effect of Fire viz Fluidity.
Most solid Bodies in a certain Degree of
Heat become fluid. most fluid Bodies
in a certain Degree of Cold become
solid. if there are any Exceptions over
to these general propositions we must
conclude that it is owing to our Defici-
-ency in applying a sufficient Degree
of Heat or Cold. the only Fluid y^t^ we
cannot render solid by Cold is Air, wch
altho it resists the greatest Cold we can
employ when alone; yet in Combination

it may be easily rendered solid.

Solidity & Fluidity do not depend upon the form of the physical Elements of Bodies, as some have imagined, but on y^e State of Heat in different Bodies; and therefore as the Form of Heat or Fire consists in Motion, so the Solidity or Fluidity of Bodies depends upon Rest or Motion.

I am conscious that many Objections may be opposed to this Doctrine by those who imagine that Fluidity depends on a certain Globular Figure of the ultimate Particles of Bodies, w^ch enables them to roll easy over each other

of Fluidity

on the least Impulse, & that on the contrary the particles of Solids are spiked and angular. they suppose likewise that the freezing of water &c: is the most common Instance of the Conversion of a Fluid into a Solid. depends upon some Saline or frigorific particles, which enter the water and entangle its Globules. The arguments in favour of this Hypothesis are fully drawn up by Mr: Muschenbroek, &c: I shall here enumerate & endeavour to obviate each by

my own Observations. –

I. It is said that water converted into Ice is expanded, this therefore cannot be the Effect of Fire but of some new Matter introduced.

Answer. Water converted into Ice yields a Quantity of Air, which it contained in its fluid State, & this being in some Measure involoped therein, as appears from the Bubbles in any peice of Ice, renders it lighter, & at the same time expands it. as

of Fluidity

a further Illustration of this we may observe that water congealed after its air has been seperated by an Air pump is less expanded, & its Specific gravity greater than usual. -

II. It is said y^t^ water may be observed to freeze at the Side first where y^e^ frigorific particles enter; hay Musschenbroek says y^t^ he has seen them enter in a kind of Stream at y^t^ part of the Phial where the Freezing began.

Answer. The Freezing beginning at a certain part of the Phial may

# of Fluidity

depend upon y^e same principles as Crystallization, namely y^t is begun where the Phial is thinnest or where the greatest Degree of Cold is applied. as to the frigorific particles w^ch this ingenious Philosopher believes he saw entering into y^e part of y^e Phial where the Freezing began, I have no Idea how they could be visible to his Eyes, & at the same time small enough to pass to pass thro the pores of Glass. I rather suppose that what he saw was Air seperated at the place where the Freezing

began.

III. It is said that water is longer fluid in close than in open vessels, & still longer in barns, because say they the frigorific particles cannot so readily have recess to the water.

Answer. Freezing water not only requires a certain Degree of Cold, but also an Opportunity to discharge its Air, which it cannot do well in barns or close vessels, because there it has not common Air to dissolve the Nitrous Air evolved during the freezing of the water.

I shall here mention a curious Expt.

of Fluidity

that occurs to my memory of wch I never have had a satisfactory Answr. If water be put into a Phial covered wth a loose Bladder tied close to the neck, it will not congeal in a greater Degree of Cold than the freezing point; but if the Bladder be pressed down by your hand, it is immediately converted into Ice if the freezing Cold prevails in ye Air.

IV. It is said that water remains fluid when the Temperature of the Air is below 32°. and congeals often when it is above that point.

Answer. This Fact so contrary to general Experience cannot be admitted, since the Experiments have not been made by such by attended to the Fallacies to which Thermometers are liable. - for musing them in Chambers - from their being in Contact w^th^ large Bodies y^t^ are not suddenly altered in their Temperature such as the walls of a House, & lastly from not observing the Interval of time between the Effect produced, & the Examination of the Instrument. before this Aug^t^ can be established we must find y^t^ water a

of Fluidity

Thermometer plunged into water in its fluid State sinks below 32°. and y. When congealed the Therm.r rises above 32°. — Mr Musschenbroek does not pretend to have made these Experiments himself.

V. — The Appearance of Frost & Snow sh. be very uniform; yet in places so near each other that no Alteration of Temperature can be supposed, Frost & Snow are in some of them as in a State of Frost, in other un-dergoing a Thaw. —

Answer. Still here it has not been observed whether the places where y. different Effects were produced were also of y. same Tempera-ture

Fluidity.

Moisture retains warmth more than dry Air. hence at the Sea side no Frost is often observable, when at a little Distance its Effects are very apparent. But in those Cases I have always found a Difference of Temperature by the Thermometer. this may arise from various Circumstances. Besides the mere Temperature of the Air other Causes concur for the congealing of water, the chief of which are the Vapour arising from the Earth. in all cases where this Vapour is intercepted, the Snow continues longer than usual even in Dunghills where a greater Degree of

generally perceived. Dr. Hales on Survey-
-ing a Field found only one particular
part of it covered w.th Snow below which he
also found a Stone Conduit. I have
regularly observed the Truth of this Ob-
-servation, that wherever I observe Snow
melt sooner than usual I conclude there
is a lax pervious Soil; — in places where
it remains longer, I conclude the Soil is
hard and rocky. —

VI. In this Argument M.r Musschenbroek
adduces an Experiment w.ch has been
reckoned decisive. if Water in a Vessel,
be put into Another containing Snow, &

of Fluidity

both applied to the Fire, the Snow in the external Vessel will be melted, the water in the inner will be congealed. The frigorific particles are therefore driven from the Snow to the water.

Answer. To this we need only reply that the Solution of Snow like other Solutions generates a considerable Degree of Cold, it is not so much diminished for a short space of time, as not to be capable of congealing the water in the inner Vessel, provided it is near the freezing point. —

VII. It has been said that Salt put

round a bed it occasioned a congelation by transmitting their Saline particles: but this Supposition is Overthrown by considering that many Salts produce heat from a Combination w: th water, and that they always impede the Effects of Cold, & render the water more tenacious of Fluidity.

VIII. Again, it is said y: Cold is more frequent, and intense in plains where y: Earth is more impregnated w: th Saline particles - an Instance is adduced from Tournefort who found a greater Degree of Heat at Paris than at Armenia. But

Of Fluidity

these Obervations prove only y^t^ y^e^ Cold is not in proportion to the Latitude of the place. there are many circumstances y^t^ may have an influence on different Climates i^z^ the Elevation of the place above the Level of the Sea, I have found by Trial y^t^ we may measure the Heights of Mountains as well w^th^ a Thermometer as w^th^ a Barometer. there are certain Heights at w^ch^ freezing always takes place, & at any place of y^e^ Elevation Snow always remains unmelted. M^r^ Gugenet has drawn a Line of Congealation & shown its gradual Descent to y^e^ South,

wch is very useful in this view. 2nd Elevation & Latitude being given the Cold is greater in proportion to the Distance of the Sea. hence Tornefort observed a greater Degree of Cold in Armenia than at Paris. Edinburgh & Petersburgh are nearly in the same Latitude, yet the latter is further from the Sea, & accordingly we find a great Difference of Temperature.

IX It is alleged that Snow-water differs from pure Fountain water. Olaus Borrichius found that the former would not answer all the purposes of the latter. There is no occasion to refer this Difference to frigorific particles. The

accurate Magraaf has found y^e^ y:^e^ melted Snow is harder. But as there is a Difference between boiled & Spring water from y^e^ Extri:=cation of Air from the former so in the same manner may there be a Difference between melted Snow & water, as the latter may be sometime in Absorbing its proper Quantity of Air w:^ch^ encreases its power as a Menstruum.

X. - The Inhabitants of the Alps from using melted Snow are liable to a Disease called Gutter tumidum.

Answer. all the Inhabitants who drink melted Snow are ^not^ Afflicted w:^th^ this

Disorder. nor is it observed in other Mountains as the Andes in America where Snow water is used as freely as on the Alps.

XI. It is said y^t Ice does not increase in thickness according to the Cold; this is because you must be owing to y^e Exclusion of frigorific particles by the Ice already formed.

Answer. the Ice resists considerably y^e Communication of Heat. the water likewise being enclosed by the Ice as it were in a shell cannot evolve its fixed air.

XII. It is said we frequently observe

# of Fluidity.

Ice on Water during the Night, & yet a little After Sun-Rise the Surface will be covered with a thin Crust of Ice. the Cold during the Night was not therefore sufficient for this purpose, but in the Morning the frigorific particles were brot into the Atmosphere, & a Congeala=tion imediately produced. —

Answer. I have often Obrerved this Phæ=nomenon, & agree w: the Mr Mushen: 2 4: the Cold during the Night was not Suff.: to produce the Effects Yet it was so near the freezing point than When y Sun

arose, and an Evaporation began to commence, a greater Degree of Cold was produced, & in Consequence of it a Congelation.

XIII. The Effects of Acids upon Ice are not the same as upon Water. This must therefore be owing to some extraneous matter.

Answer. In innumerable Instances we find that a Difference of Aggregation causes a Difference in the Properties of Bodies without the Admixture of any new matter. From considering therefore the Discussion of these Arguments you will

of Fluidity

See the Truth of 2d w: we alledged, that the Freezing & Congelation depend upon a certain Degree of Cold, & 4ly: That is no Foundation for thinking they are connected w: any Figurative Particles.

That are some Special Phanomena 4th w: Regard to the freezing of water 4th w: have given Occasion to this Dispute. That in some Bodies the Change from a solid to a fluid State is by gradual & all possible intermediate Degrees, without our being able to assign the exact period of Fluidity & Firmness: Water on 2d contrary passes from the one State to the other in a Moment.

wax is given as an Example of the former Change. there are however very few Bodies that do not concrete at a certain time. it has been imagin'd by some y^t the Concretion of metals is analogous to y^t of wax. but Reau-=meur has shewn y^t it is more analagous to water; and in Sp^t of wine & several oily Bodies the Concretion is as sudden as that of water. the Cause seems to be this. there is always in water a certain proportion of Air at a certain Degree of heat in a fixed State. if the heat is diminished the power of the water to

of Fluidity

a menstruum is diminished, & so a quantity of the Air is set free. 4ly Fluidity of the water seems to depend in a great measure upon the presence of fixed Air, so that as soon as it is extricated by a sufficient Diminution of Heat the water becomes solid.

The same thing happens to all other Bodies liable to a sudden Congelation. 5ly. French Academicians who went to Lapland found the Spirit in their Thermometers suddenly frozen & raised higher than before it expanded by the fixed Air extricated & restored to a fixed State. Reaumeur found

also in metals. as for Instance: Iron
that they also expanded at y^e Instance of
Connection: owing to the Elasticity pertain-
to the extricated Fluid as before. -

You see then the great probability of
Fluidity depends upon Heat. Why this
Cause operates so unequally depends upon
peculiar properties in Bodies which have
hitherto been unexamined & unexplain-
-ed. ——

# of vapour

The third general Effect of Heat is the Conversion of Bodies into vapour. The Evaporation of Bodies may be considered as of two kinds 1st the Solution of different Bodies in a State of vapour 2d the Conversion of Bodies to vapour when every particle repells another, and becomes as it were the Centre of an Atmosphere. –

The Solution of Bodies in vapour seems to be the Cause of several Phaenomena, particularly the Ascent of Water of water from the Earth in a State of

Of Vapour

Vapour, &c w: certainly for the most part depends on Solution. Nothing is more certain than that water Absorbs air and fixes it, & again that Air carries off water, & volatilises it. So Air like Other menstrua acts in the Solution of water acording to its Dryness, Heat & Density. And if this is true y^e Laboured Hypothesis of Desaugliers & Other must fall to the Ground. The Hypothesis is very plain, & exactly consistent w: &c all the Phaenomena.

The Ascent of water into the Air when boiling is owing to Heat, in all Other

Cases it is owing to Solution.

The Conversion of Bodies into repellent Vapour takes place both in Vacuo & in the Open Air. After this begins to rise copiously no further Degree of Heat can be produced in the Liquor or Other Matter. This Conversion of Bodies into Vapour at a certain Degree of Heat occurs in all Bo=dies.

Besides Fluids a boiling point is observed in many Solid Bodies reduced to a fluid Form. Of the Metal: Class. Now are none but Gold & Silver w: cannot be brot to the point of Evaporation in Chemi=cal

of vapour

Furnaces; & even there in y Focus of
of a burning Glass have been conver-
-ted into vapour. if some Earths are
capable of resisting this Heat, it may
be fairly attributed to the Defect of vio-
-lence in the Heat w^ch^ we can apply, &
therefore our Proposition will remain
" that in all Bodies a boiling point oc-
-curs w^th^ all its Circumstances "

The Phaenomena w^ch^ occur generally
in boiling are 1^st^ that when Water receives
a Quantity of Heat it is expanded without
losing its Transparency. if After some time
we look Obliquely into the Glass vessel

containing the water we shall perceive an intestine motion & Stria formed. After this the Transparency is disturbed, but recovered before boiling. —

When the Transparency is thus recovered Bubbles arise from the Bottom, & other Bubbles w^ch were before at the Sides rise to the top, and dissolve. towards y^e boiling point the Bubbles rise most copiously, & at that point numerous & large Bubbles fly up to the Surface and explode. in this fluid the hissing of the Bubbles is not so quickly performed. from y^e moment two a part of the liquor is dissipated in y^e air.

of Vapour

Let us now endeav^r to ass^t for these Phanomena. That Bubbles w^ch occur in boiling, must not be mistaken for Air or any other Fluid w^ch can be contained in Vessels. Dr. Boerhaave relates an Exp^t from Mariotte by w^ch it appears that the Bubbles easily peirce thro Glass and escape. Pollet relates Something of the same kind w^th regard to Mercury. Over a Bottle of which he tied a Bladder very accurately, made the Fluid boil - and found y^t by Sublimat^n he exhaled as easy, as if the Bladder had not been there. from this it appears y^t

of Vapour

It is not Air, but a Subtile matter
passing from the burning Fuel into
the Water that occasions y^e Bubbles.
– all the other Phanomena may be
explained upon the same Principles.
– The Expansion necessarily ensues
on the Entry of the Elastic Fluid. in most
Fluids uniting this occurs if properly view'd
a similar Appearance of Ebullition from the
motion of the One thro the other. in Con-
sequence of further Diffusion, but not
proper Vapour, more or less Capacity
occurs, w^ch Afterwards disappears when
the Mixture becomes more perfect with

Of Vapour

much the same Appearances does the
Mixture of Alchohol & water take
place. first this appears ch. w: go off, &
are succeded by a milky Appearance
ch w: when the mixture is finished becom-
ing again transparent. —

all these Phanomena tend to shew us
y: in boiling a new matter is gradually
furnished equally dispersed thro the water.
at length a certain Quantity being intro-
duced the water can retain no more, but
the Elastic Fluid leaping into it form those
Bubbles which appear at the Bottom,
& ch w: in Consequence of their Elasticity &

# of Vapour

less Specific Gravity rise up to the Top. so that all the Fluid y^t^ enters the water after the point of Ebullition flies off. This does not depend on the nature of y^e^ water but is influenced by the pressure of the Air on its Surface: and according as this pressure is greater or less, the water will retain a greater or less quantity of the Elastic Fluid, & the Phaenomena of Ebullition occur sooner or later. This by an Experim^t^ of M^r^ Montesquieu Sen^r^ it appears y^t^ as we ascend higher into y^e^ Atmosphere, Water boils sooner, on the other hand in a Digestor in w^ch^ Air is in-
cluded

& w^h by heat will be enabled to exert
its Spring. the water may be heated
without boiling. to any Degree of heat
w^h the Strength of the Vessel can bear.

As soon as water boils a Dissipation
begins. This Dissipation as carrying
away part of the mass of water, & conse=
=quently of the Fluid conjoined w^h it might
be supposed to cool the Liquor, but the Elas=
=tic Fluid enters in as great proportion
as it is carried off by Dissipation. w^h we
would chiefly infer from this is, a pretty
strong proof that the Action of Fire on

of Vapour

Bodies depends on a Subtile Fluid encir-
-cling them, in certain Circumstances in
a greater or lesser proportion. The Exis-
-tence of such a Fluid being granted, we
can conceive how it may determine
the Aggregation of Bodies. to explain
its Effects a Postulatum must be assumed,
which indeed may be in some measure
proved Viz: if the Atoms of Bodies ap-
-proach to a certain Degree of Contiguity
the other interposed between such contigu-
-ous Atoms will act up powerfully than
that which is without them. This granted

we can Account for the Differences of Aggregation.

When two Atoms approach so near y^e^ the Action of the Other without them, overcome that of the Other between them, those two Atoms will be presed together & form a Solid. This will be more Cohesive in proportion to the closer Contiguity of the Atoms.

The Attraction in the Expansion of a Body will depend of the Quantity of Other in a Body. When this is in such a Condition that the Action of y^e^ external & internal Other are in a Ballance y^e^ Body

of Vapour

becomes fluid. if we proceed to suppose that the internal overballances the external Aether, then every particle is surrounded w:h an Elastic Atmosphere of ch: It is the Center, repelling every Aether particle surrounded in the same manner & again repelled by these. a Body then will be in the State of Vapour.

Besides the Effects of Aether already mentioned, it is probable y: by y: Interposition of the Aetherial Fluid, the boiling Liquor is never in actual Contact w:h y: Bottom of the Vessel. This will Acc:t for w:h happens to heterogeneous Masses exposed to boiling.

viz: that before boiling they are decom-
-pounded, & let fall a Matter to the
Bottom, w^ch sticking to the Vessel is
more heated than the rest of the Liquor.
but if we can prevent y^e sticking of this
matter till the boiling begins, there is
afterwards no Danger of such an Accident.

Again. formerly Observed y^t in Chemical
Operations we should never use such Vessels
as are corroded by the Matters to be put
in them. it is known however that Modern
on the Acc^t of the Convenience of Copper
Vessels, often boil Acids in them without

of vapour

bad Effects; but they always take care to pour them in without boiling, during w^ch time, by means of the Elastic Atmosphere they are prevented from touching y^e Vessel. — If in any Case the boiling Liquor is of considerable weight & viscidity, insomuch as to hinder the Ascent of the Vapour, and force it back on the Bottom of the Vessel, it is easy to see that acting Ag^t the Bottom & Sides very powerfully, it will break the Vessel: hence y^e necessity of thick Bottoms to Crucibles. —

If one Vessel of water be put into another Vessel of water, the water in the

inner vessel will never boil, altho' the heat come up to the boiling point. Water can receive only a certain Degree of Heat, for after this the other flies off as fast as it enters. all this other comes from the proper surface of the external vessel, and therefore w: is superfluous heat of this the water it contains, without entering the inner vessel. hence there is no appearance of Ebullition of y: latter.

Tho we can explain thus y: Phenomena of boiling, yet we are no more in a condition to explain why it happens in different

of Vapour

Bodies at different Degrees of Heat, than we formerly were to explain under the Head of Fluidity why Heat acted with such various Effects on different Bodies. —It is probable however that it does not depend so much upon a Difference of Mixture in Bodies as on their State of Aggregation; for the Phaenomena of boiling occur only in such Bodies as are homogeneous, & suffer no Decomposition during boiling. Thus Oils have no boiling point since they are decomposed by a boiling Heat; some parts flying off & others remaining behind w: after the

# of Vapour

State of the Liquor, & its Aggregation.

In decompounded Liquors another Difficulty occurs; for when the Vapours arising from them are condensed, they do not assume the usual Form of the Fluid, as happens in the Vapours of homogeneous Fluids. Hence Vapours may be either the constituent parts of a Mixt, or of the Integrant parts of an Aggregate.

a Question properly occurs here. Why Solid Bodies are more subject to be decompound by Evaporation than fluid Bodies? — To attempt a Solution of this we may say that Fluids do not resist the

of Vapour

fraction of Fire as much as Solids, and therefore are raised together. Whereas Solid Bodies often require such a Heat to fuse them as Aggregates, as is sufficient to decompose them as mixts.

— Thus in the Calcination of Antimony while it continues in powder, it suffers a Decomposition, and y^e^ sulphureous parts arise only. Unless on the other hand the heat is raised to such a Degree as to cause a Decomposition of the Metal.

# of Ignition

The Fourth, & next Effect of Heat w^ch we shall mention is Ignition. This is in some measure common to all Bo=dies w^ch can sustain a sufficient Heat without Dissipation. Ignition is attain=ed w^th a certain Degree of Light of a red Colour, tho' it differs from Inflam=mation. the former is an Affection of the whole Mass; the latter is confined to the Surface of the vapour of Bodies. Ignition take place wherever a sufficient Heat can be applied to Bodies capable of it. Thus by the help of a Lens we can ignite Bodies in water or Vacuo. on the contrary --

# of Ignition

Inflammation cannot take place with-
out a free accession of common Air.
Wherever Inflammation happens a
Decomposition takes place, but Ignition
is not an affection of particular Bodies.
It is common perhaps to all Bodies w.
an capable of bearing a certain Degree
of Heat without Dissipation. we cannot
prove this from actual Experiment,
but it plain from Sir Isaac Newton's Scale
of Heat. that Ignition occurred at the
same Degree of Heat in all the Bodies he
tried. Sometimes it is attended with

of Ignition

Inflammation & Evaporation. these however are the Effects of particular causes. —

5ly Of Calcination. This Effect of Heat tho usually confined to particular Bodies, is perhaps common to all. Its Effects are to change either Fluid or Solids into a powdery friable matter. in Mercury this was long ago observed. But it is now established by Experiment 2ly: water & Alchohol may now be made to undergo the same change. Boyle's Exp: have been confirmed by Geoffroy. &

# of Calcination

Margraaf has shewed the Effect in water. It happens in all kinds of Bodies to wch a sufficient Degree of Heat can Legion, and which will retain it. Gold & Silver are the only Exceptions, and there is Reason to suspect the same of these.

It appears that most Bodies when calcined sufficiently acquire an Increase of weight. This does not happen from the Air since the same thing happens in Vacuo nor by any grosser matter from our Culinary Fires, since the Effect appears when the Calcination is performed in the Focus of

a burning Glass. Tho' we have alledged, & I hope with some Reason, that the Phaenomena of Fire depend upon a Subtile Fluid, yet we must allow y^t it is not entirely free of gross matter, as in y^e Case of Air, and the Electrical Fluid we suppose have some y^e Additional weight is caused by the Intrance of the gross matter of the Fluid into the calcined Substance. Some suppose this to be owing to the particular matter of Fire & M^r Boyle alledges it as a proof of the Ponderability

of Calcination

of Fire & Flame. considering ye State of the other Phanomena we cannot imagin it to be Fire itself, wch gives the weight, but rather the grosser matter adhering to it. —

6th: of Vitrification. In ye ordinary manner in wch we see this take place, it seems to belong to certain Matter only. Others however have maintained that it is a universal Effect of Fire. we shall not here enter into this Dispute, but only mention two Facts wch are relative to it 1st: that in every Case of Vitrification it is preceded by Calcination, either as

Of Vitrification

in the Case of Metals when melted &c.
or in other Cases by the Addition of
proper Matters. 2.ndly It is constantly
attended w.th a Change of the Body from
an Opake to a transparent Substance.
It is always necessary to the Transpa-
rency of Bodies that they convert
in to thin plates. We know y.t most
natural transparent Bodies are
composed of such thin plates as Crys-
tal Diamond &c, w.ch may be either
seen or inferred from Experiment.
in Artificial Glass it is very difficult

of Vitrification

to discover this Structure. it may how-
-ever be rendered evident by Decompo-
-sition: for if we make Glass w:th an over-
-proportion of Alkali, and apply an
Acid to it, it may be seperated into
thin plates like the Leaves of a Book.
do y:e we have Reason to conclude y:e
Connection was in the same Manner.

of Inflammation. In treating of

the Latter Effects of Fire we endeavoured
to arrange them acording to the Degree
of Heat they required, beginning w:th those
which required least: do y:e in this View

# of Inflammation

Inflamation might have been spoken of more early.

We have mentioned formerly that this is an affection of the texture of Bodies. of all the Effects of Heat likewise, it may be most properly considered as depending of the particular Nature of a Body. - Notwithstanding the great Diversity of Inflammable Bodies, we have given Reasons for supposing that they may all be comprehended under 2 Articles of Oil, Sulphur & Alcohol.

This Division I found to be proper under the Chemical History of

of Inflammation

~~Bodies~~ Inflammables. I would not however contend y: it is quite neat. for will a Diffusion of the Matter be necessary sure, if we can find a common matter on which Inflammability depends.

— The three Substances above mentioned are extremely analagous to each other. I believe they are all Compound Bodies that Phlogiston is also a Compound Body. an Acid enters into the Composition of each of them without w: ch no Inflammable Substance has been yet found. It w: coni= =derable proportion it may enter into some

Of Inflammation

of Nitre appears from the Analysis of Sulphur. From the constant presence of an Acid in Inflammable Bodies from the Convertibility of an Acid into an Inflammable & vice versa, we are led to conclude that an Acid is absolutely necessary to Inflammability: but Acids by themselves are not inflammable, we conclude also that some other Substance must be united with an Acid to produce Phlogiston, and that therefore it is a Compound. This other Ingredient may probably be fixed Air, for we know certainly that it always

of Inflamation.

arises from burning Bodies. This notion was formerly prevailed but it might be illustrated from the Composition and Decomposition of Sulphur. at any rate by proving that Phlogiston is a Compound we have no Room for supposing that Fire is an Elementary Substance, and take off the necessity of Attributing all the Effects of Fire to a peculiar Mixt, this we may easily allow it in Inflammation. — Another Circumstance in Inflamation must be Observed viz. the necessary Concurrence of Air. a Question however occurs.

# of Inflammation

Whether Air be a Pabulum Ignis, or Matter of Inflammation? It appears that Air does not afford a Pabulum, since other Elastick Fluids in which we have no grounds for supposing a Pabulum, will equally well serve the purpose. nay Air seems rather to absorb some matter evolved during Inflammation, which if not thus taken away would extinguish the Flame. The Breathing of Animals is somewhat analagous to this; for the same Air is necessary to Breathing as to Inflammation, & that which is improper for the One is improper likewise for the Other.

of Inflammation

hence it is probable, that the Air serves the same purposes in both Cases.

I refer you to Dr Hales's Experiments on those Subjects of Breathing & Inflammation, for many Facts relating thereto. That the Matter exhaled from the Lungs is fixed Air appears probable from its Effects — in rendering Caustic Alkali mild — extinguishing Flame &c. —

Finis.


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